I HAVE eaten your bread and salt,
I have drunk your water and wine
The deaths you have died
I have watched beside,
And the lives ye live were mine

Was there aught that I did not share
In vigil or toil, or ease
One joy or woe that I did not know,
Dear hearts across the seas?

KIPLING.

TO

MY WIFE

WHOSE CHEERY COMRADESHIP HAS

LIGHTENED THE BURDEN OF MANY LONG YEARS

OF TROPICAL EXILE

PREFACE

The question of colonization of the tropics is now being seriously discussed, not only by physicians, but by statesmen, in every quarter of the globe, and the present trend of thought is indicated by the following quotation from Meredith Townsend's "Asia and Europe":

"It is probably much more possible for white men to colonize a tropical country than is imagined, especially if the colony was so organized that sanitary laws could be enforced from the very first."

Whatever may be said on the subject of actual colonization, one point is universally conceded—namely, that by the knowledge and application of hygienic principles the health of white residents in the tropics may not only be conserved, but maintained in full vigour for prolonged periods.

Curiously enough, although the subject of tropical medicine is dealt with in numerous books, the kindred one of tropical hygiene has hitherto been much neglected.

The author trusts that, as this little work is in many ways the first thing of its kind, its numerous

shortcomings may receive consideration, if not condonation.

He acknowledges his deep obligation to the authors in the list of references, from all of whose valuable works he has freely quoted, but it has been obviously impracticable to indicate in a book of this nature the source of each quotation.

The author's special thanks are due to his friend, Captain Acton, I.M.S., Director of the Pasteur Institute of India, who has read over the proof-sheets and made numerous practical and helpful suggestions.

R. J. B.

PESHAWAR.
June, 1912.

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AIDS TO TROPICAL HYGIENE

CHAPTER I

CLIMATE AND METEOROLOGY

THE present-day distribution of civilization supports the view that tropical or subtropical regions are unsuited to the more civilized races. Our most progressive communities are located in temperate regions, and any invasions of the tropical or semi-tropical zones by representatives of northern civilizations have either suffered rapid decline or have been kept vigorous only by constant reinforcements from their source.

However, this superiority of the colder latitudes as a place for human development has not always existed. Almost without exception, the parent sources of human progress have been in tropical, or at least in subtropical, countries. Mesopotamia, Egypt, and Asia Minor, all represent sites of apparently original civilizations, and are located well within the warmer zones. The mysterious relics of Central America and Mexico on the one hand, and of Peru on the other, are so situated. It is true that in this latter case the altitude is such as to change climatic condition ; but there is evidence to show that marked elevation has taken place comparatively recently, and that the more ancient remains in this region actually antedate this elevation.

If, then, the tropics, originally the source of human culture, have been incapable of maintaining it, some

change in condition must be responsible. The probable explanation lies in the spreading of the peculiarly tropical diseases, due to the increased exchange of people and products so characteristic of later years. The decline of Greece and Rome have been ascribed to the introduction of malaria along with African slaves, and in America we have even better-established instances of this sort. Torquemada, speaking of Yucatan, itself a site of prehistoric civilization, says: "Men die of pure old age, for there are none of those infirmities that exist in other lands; and if there are slight infirmities, the heat destroys them, and so there is no need of a physician there." But with the coming of the white man and the negro, and their alien diseases, conditions changed until Southern Mexico and Central America became notorious as hotbeds of tropical fevers.

With progress in sanitary science, this position of the warmer latitudes may undergo another alteration, and already in Cuba and Panama the possibility of mastery over these diseases has been shown.

The Climates of the Tropics.

The tropical zone, which embraces nearly half the earth's surface, has been bounded—

1. By the Tropics of Cancer and Capricorn, latitude 23° 5′ north and south.
2. By the mean annual isotherms of 68°.
3. By the polar margins of the trade winds.

The region has been divided into three belts, viz.:

1. The equatorial belt.
2. The trade wind belt.
3. The monsoon belt.

The dominant characteristic of all tropical climates is the regularity in the occurrence of the ordinary weather phenomena.

They lack the proverbial changeableness which characterizes the weather of higher latitudes.

In special regions only, and at special seasons, is the regular sequence of weather temporarily interrupted by an occasional tropical cyclone.

The devastation produced by one of these storms often affects the economic condition of the people in the district of its occurrence for many years.

The following points with reference to tropical climates require consideration :

1. Temperature.
2. Seasons.
3. Barometric pressure.
4. Winds.
5. Rainfall.
6. Storms.
7. Tropical sunlight.
8. Altitude.
9. Physiological effects of tropical sunlight and heat.

1. **Temperature.**—The sun reaches its highest azimuth in the tropics. The length of the day and night varies little. Hence the mean temperature is high, it is very uniform over the whole zone, and there is little variation during the year. The mean annual isotherm of 68° is a rational limit at the polar margins of the zone, and the mean annual isotherm of 80° encloses the greater portion of the land areas, as well as much of the tropical oceans. The isotherms are thus far apart. The warmest latitude for the year is not the equator, but north latitude 10°.

2. **The Seasons.**—In a true tropical climate seasons do not exist. The variations in temperature throughout the year are so slight that the seasons are not classified according to temperature, but depend on

rainfall and the prevailing winds. The life of animals and plants, and of man himself, in the tropics is regulated very largely by the rainfall. Agriculture prospers or fails according to the sufficiency and punctual appearance of the rains. After a long dry season, when the rain comes, there is a remarkable sudden awakening of the parched and dusty vegetation ; but where, as frequently occurs, there is abundant moisture throughout the year, a tree may at the same time be carrying buds, blossoms, and ripe fruit.

3. **Barometric Pressure.**—The annual barometric fluctuations are slight, even on the continents. The diurnal variation of the barometer is so regular and so marked that the time of the day can be told within fifteen minutes if the reading of the barometer be known.

4. **Winds.**—There are two conditions which prevail in the tropics :

(1) Calms.
(2) Trade winds.

(1) *Calms.*—Where the pressure gradients are weakest — that is, along the barometric equator—is a belt characterized by long periods of complete calm, called by sailors the "doldrums."

(2) *Trade Winds.*—In striking contrast to the doldrums are the easterly trade winds, blowing between the tropical high-pressure belts and the equatorial belt of low pressure. These supply the first belt with a constant flow of warm air, which already contains a large amount of water vapour, evaporated from the oceans by the trade winds. This saturated air needs only a comparatively high temperature to produce condensation, and thus give abundant rainfall.

These winds blow over nearly half the earth's surface, and add greatly to the uniformity of tropical

climates. They have long been favourite sailing routes, because of the infrequency of storms, the brightness of their skies, and the freshness of the air, all of which are in pleasant contrast with the muggy and oppressive calms of the equatorial belt.

These winds, called in the rainy season the "monsoons," control the seasonal changes of tropical lands.

5. **Rains.**—The most important climatic phenomena of the year in the tropics is the rainy season. Tropical rains are in the main summer rains—*i.e.*, they follow as a general rule soon after the "vertical sun," the rainy season coming when the normal trade winds give way to the equatorial belt of rains or when the summer monsoon sets in.

The tropical rainy season is by no means a period of continuous rain, falling steadily day and night week after week. The mornings are often fine and the air comparatively bracing, so that the season at some fashionable places, such as Poona, is during the "rains."

6. **Storms.**—Local thunderstorms are frequent in the humid portions of the tropics. In Northern India hailstorms of great violence occur, and persons have been killed by them.

7. **Tropical Sunlight.**—The intensity of the light from tropical skies is trying to new-comers. The intense insolation, together with the reflection from the ground, increases the general dazzling glare, and necessitates protection of some sort.* The far-famed deep blue of the tropical sky is much exaggerated. During much of the time, smoke, dust, and water vapour, give the sky a pale, whitish appearance. The beauties of the tropical sunrise and sunset, and of the tropical night, have, however, *not* been over-

* The use of blue, smoked, or neutral tinted glasses is recommended to prevent glare and dust affecting the eyes and causing pterygium. Their use also keeps the excessive feeling of heat from striking one so forcibly.

rated. Twilight within the tropics is shorter than in higher latitudes, but the coming on of night is less sudden than is generally asserted.

It is obvious that sunlight in equatorial and sub-equatorial regions will be more potent than that of more temperate zones; for not only does the perpendicular course of the rays make the intervening protective layer of the atmosphere relatively thinner, but it also results in a greater intensity of illumination for any exposed area. The actual occurrence of this greater power is readily shown by measurement of the chemical activity of tropical sunlight as compared with that of colder latitudes, and, possibly as a result of such experiments, the idea has been prevalent that the harmful effect of sunlight is primarily due to the chemically active (actinic) rays. It was because of this idea that orange-coloured underwear was tried on soldiers in the Philippines, an experiment which, as is shown in Chapter V., was unsuccessful. The other view, that it is the infra-red heat rays that are the most harmful, is held by Aron, and he advances experimental evidence in its support. (*Philippine Journal of Science.*)

His most interesting experiments were obtained with apes. In these anthropoids the surface temperature is normally ½° to 1° lower than the internal temperature, but on exposure, if only for a few minutes, to sunlight, this relation became reversed; if exposed long enough to cause death—which takes only a short time for these animals—the superficial temperature exceeded the deep by 1½°. Shaving the animals emphasized these differences, and shortened the fatal period markedly. If a current of air was kept in circulation over the exposed animal, it was capable of resisting the action of sunlight indefinitely. Conclusive evidence against the supposed direct action of the actinic rays on the meninges was afforded by

a simple experiment. An ape was encased in a double-wall box in such a way as to expose its head only to sunlight. Absolutely no harm resulted to the animal, although a superficial scalp temperature of 116·5° F. was attained.

The effect of sunlight on human beings was also studied. The normal human surface temperature was found to range from 90° to 92° F., but on exposure to sunlight this rose rapidly to 96° and 97° F. Further exposure resulted, not in a further rise, but in an actual drop of ½° or 1°, coinciding more or less closely with the appearance of perspiration. With muscular exertion this fall was both greater and more rapid. In general, coloured individuals did not attain as high superficial temperatures as did the white, although, from the greater absorptive powers of pigmented skin, the reverse would be expected. This is held to be due to the earlier onset of perspiration, possibly occasioned in part by the greater absorption. The coloured individuals have an advantage in their ability to go uncovered without any danger of the painful solar dermatitis to which white men are so subject.*

The chief importance of Aron's work lies in its overthrow of the "actinic theory" of solar action. It is obvious that this more correct knowledge of the effect of the sun's rays makes possible the adoption of rational means of protection against them, and so affords an additional step towards increasing the habitability of the tropics for races of northern origin. (*Journal American Med. Association*, 1911.)

8. **Altitude.**—Within the tropics altitude is chiefly important because of its effect in tempering the heat

* Acton dissents from Aron's view, and holds that the pigment cells (melanoblasts) form a protective filter screen for the cutis-vera, and protect the vessels, etc. Although absorption of heat may be greater for coloured skins, it is counterbalanced by the larger and more numerous sweat-glands which extract heat by evaporation.

of the lowlands, especially at night. If tropical mountains are high enough, they carry snow the year round, even on the equator, and the zones of vegetation may range from the densest tropical forest at the base to the snow on the summits. The highlands and mountains within the tropics are thus often climatically in sharp contrast with the lowlands, and offer more agreeable and more healthful conditions for white settlement. The climate of many tropical plateaus and mountains has been happily described as a "perpetual spring."

9. **Physiological Effects.**—The continuous moist heat of the tropics renders the tropical resident very sensitive to slight temperature changes, which are readily borne in drier climates. A fall of the thermometer to within a few degrees of 70° seems to some tropical natives almost unbearable cold, and certain African tribes sleep on clay banks heated inside by fires, although the mean temperature of the coldest month is over 70°. The tonic effect of a cold winter is lacking, and after prolonged residence, energetic physical and mental action is often difficult, and not infrequently distasteful.

Meteorology.

Meteorology is the science which has for its object the observation and interpretation of atmospheric phenomena.

The phenomena which concern the tropical hygienist are—

1. Temperature.
2. Atmospheric humidity.
3. Rainfall.
4. Atmospheric pressure.
5. Winds.

1. **Temperature.**—Temperature is recorded by thermometers, and the varieties with which the health

officer is concerned are — (1) The ordinary, (2) the maximum, and (3) the minimum.

(1) *The Ordinary Thermometer.*—This instrument is too well known to require any description.

(2) *The Maximum Thermometer.*—The best variety is Negretti and Zambra's, as it is less liable to get out of order than Phillips' thermometer.

Registration is effected by the mercurial column itself in the following manner : The bore of the thermometer tube is reduced in section close to the bulb in such a way that, whilst the expansion of the mercury is sufficient to force the liquid past the obstruction, the cohesion of the metal is insufficient to draw it back again when the temperature falls.

If the instrument be set so as to agree with an ordinary thermometer, and be examined after a time, when the temperature has risen above that which was prevailing when the setting took place, the amount of mercury in the tube above the contraction will represent the precise amount of mercury forced past the contraction when the temperature was highest, and thus will measure the temperature. The thermometer should be slightly inclined, bulb downwards, before reading, so as to let the separated portion of the column flow gently back to the contraction.

In order to set this thermometer, it should be held bulb downwards and shaken. The weight of the separated mercurial column will have the effect of causing all the superfluous mercury to return, past the contraction, into the bulb, and the instrument will soon come to indicate the same temperature as that of the air, and will be ready for use again.

The hands must be kept away from the bulb during the process of setting.

(3) *Minimum Thermometers.*—The variety best adapted for ordinary use is Rutherford's. This is a spirit thermometer with a metallic index, which moves

with little difficulty in the tube. This index is entirely enveloped in the spirit, and the action is as follows: The index is allowed to run down to the end of the column by sloping the thermometer with the bulb uppermost, and when so set is placed in a nearly horizontal position. When the temperature rises, the spirit flows past the index without disturbing it. When, however, the temperature falls below that at which the instrument was set at starting, the force of the capillary attraction between the spirit and the index draws the latter back with the spirit. Its upper end remains flush with the extremity of the column while it is receding, and ultimately marks the lowest temperature, as when the temperature rises the index is left behind.

These thermometers are liable to a serious defect, owing to the fact that a portion of the spirit becomes volatilized, and is then condensed in the upper end of the tube, so that the continuous column is curtailed by a length of perhaps several degrees.

The temperature of the air depends upon (1) altitude, (2) latitude, (3) distance from the sea, (4) temperature of the sea, and (5) exposure. Of these, probably the two most important are altitude and latitude. The mean temperature falls about 5·5° C. for each 1,000 metres of ascent.

An *isotherm* is a line denoting equal temperature. An isothermal map is a map of an area of differing extent, which shows lines which may be either curved or straight, of equality of temperature over a given period of time. They must be looked upon as only approximately correct regarding the superficial distribution of temperature.

To find the actual mean temperature, monthly or annual, of any place crossed by an isotherm, subtract the height of the place in metres by 150 to 200, as the case may be, from the value of the isotherm in

degrees Centigrade, or the height in feet divided by 270 or 365 from the value of the isotherm in degrees Fahrenheit; by 150 where the vertical gradient averages 1° C. for every 150 metres, by 200 where the gradient averages 1° C. for every 200 metres; and by 270 or 365 respectively where the vertical gradient averages 1° F. for every 270 or 365 feet respectively. (Glaister.)

2. **Atmospheric Humidity.**—Next to the actual temperature, one of the most important of meteorological observations in the tropics is the estimation of the humidity, as most of the unpleasant effects of a tropical climate are due to excess of moisture in the atmosphere.

Two kinds of humidity are described:

(1) Absolute.
(2) Relative.

(1) *Absolute.*—Absolute humidity is the actual amount of watery vapour in a fixed quantity of air.

(2) *Relative.*—Relative humidity is generally the humidity given in meteorological tables. It is the amount of watery vapour contained in the air compared with the actual maximum.

The lowest relative humidity is 25 per cent.; under 55 is low, between 55 and 75 moderate, and over 85 is excessive.

Hygrometry is the art of estimating the amount of watery vapour in the air by means of hygrometers.

There are various kinds of hygrometers, the observations of the amount of moisture in the air being taken in a direct as well as in an indirect manner; but the wet and dry bulb hygrometer is by far the most convenient instrument for use under ordinary circumstances.

The instrument consists of two thermometers, the bulb of one of which is coated with muslin, and kept

moistened with water. The principle of its action is that, as long as the atmosphere is not saturated with vapour, evaporation will take place from any free water surface, such as the moist coating of the wet bulb. If, then, the air be saturated, no evaporation is possible, and the two thermometers, the dry and the wet bulb, will read alike. If the air is not saturated, the coating of the damp bulb will give off vapour, and the temperature of that thermometer will fall until a certain point is reached, intermediate between the temperature of the air and the "dew-point."

The *dew-point* is the temperature at which the amount of moisture present in the air would cause saturation.

The usual mode of regulating the supply is to keep a small reservoir of water close to the damp bulb, and to establish a connection from the one to the other by means of a few threads of cotton. The cotton should be long enough to reach a few inches from the lowest part of the bulb, and should be carried sideways, so as to dip in the vessel of water, when it will act as a capillary siphon and keep the bulb constantly moist.

The management of this instrument requires some special precautions—viz.: (1) The covering of the wet bulb must be very thin—else there is danger that the thermic equilibrium will not be established between the outside of the coating, where the evaporation is going on, and the actual bulb; (2) the supply of water must be very carefully regulated, so that the bulb shall be constantly moist.

The little water reservoir should be placed as far as possible from the dry, which should not receive moisture from any source whatever. Of course, if moisture be found on the dry bulb, this should be wiped and left for a while to assume the true tempera-

ture of the air. The water of the wet bulb should be distilled.

The water should be replenished *after*, or some considerable time *before*, observing, because observations are incorrect if made while the water is warmer or colder than the air.

The muslin should be well washed before being applied, and occasionally whilst in use, and should be changed once or twice a month, or even oftener. Accuracy depends much on cleanliness and a proper supply of fresh water.

Glaisher's tables give the relative humidity corresponding to all ordinary readings of the wet and dry bulb thermometers, so that the elaborate calculations given in some textbooks are rarely required.

3. **Rainfall.** — The estimation of the rainfall is always of interest in the tropics, as we have seen that the climate of a tropical region depends almost entirely upon it.

There are numerous patterns of rain-gauges, but the best for general use has a circular collecting funnel, usually 8 inches in diameter, of which the area is accurately known. The rain is caught in a receiver, and measured in a graduated glass. The upper edge of the funnel is fitted with a vertical rim about 6 inches in depth, with a stout brass ring, ground to a knife-edge on top. Great care should be taken to insure that the mouth of the funnel is not dented, for if the area be not a true circle the full amount of rain will not be collected. The sole reason for preferring circular gauges to square ones is that the latter get more easily out of shape than the former.

The rainfall varies enormously in various parts of the tropics and subtropics. In India, for example, it varies from about 5 inches in Sind to 120·6 inches on the Malabar Coast, 253 at Mahabaleshwar, and 600 inches at Cherrapunji in the Khasia Hills, Assam.

The amount of annual rainfall has no direct relation to humidity; for instance, Lima, on the Peruvian coast, has a very humid climate, but is almost rainless.

Similarly, Karachi has a damp atmosphere, but an annual rainfall of only about 7 inches.

As a rule, the nearer a place is to the equator and the sea, the greater the rainfall; but this rule does not always hold good, as is evident by the above reference to Lima and Karachi.

When the rainfall is scanty, the climate is as a rule hot and dry in summer, and the summer range of temperature very high.

4. **Atmospheric Pressure.**—The pressure of the atmosphere is measured by barometers, which are of two kinds—viz.: (1) Mercurial, (2) aneroid.

(1) *The Mercurial Barometer.*—The Kew, Fitzroy, and Fortin, are well-known varieties of this type of instrument. They consist essentially of a tube of glass about 34 inches in length, closed at one end, filled with mercury, and placed vertically, with the open end dipping into a reservoir containing mercury. The mercury should be pure, of the specific gravity of 13·594. The mercury does not entirely fill the tube so placed, but, according to the changes of the atmospheric pressure, occupies at the level of the sea from 31 to 27 inches of the tube, measured above the mercury in the cistern. The space above the mercury in a properly filled barometer tube contains nothing but a little of the vapour of mercury.

Another familiar type is the siphon barometer, in which the trough or cistern, as it is technically called, is dispensed with. The mercury is contained in a **U**-shaped tube, the shorter limb of which is open at the end. The reading of the barometer is the difference of level in the two legs.

The wheel barometer is a variety of siphon barometer in which the movements of the mercury are

conveyed by a simple mechanical contrivance to a pointer which indicates on a dial the weather condition usually associated with various barometric readings.

(2) *The Aneroid Barometer.*—For ordinary use in the tropics these are in great favour, on account of their convenient size and portability.

In the aneroid, atmospheric pressure is measured by its effect in altering the shape of a small hermetically sealed metallic box, from which almost all the air has been withdrawn, and which is kept from collapsing by a spring. The top of the box is corrugated. When the atmospheric pressure rises above the amount which was recorded when the instrument was made, the top is forced inwards, and, *vice versa*, when pressure falls below that amount the top is pushed outwards by the spring. These motions are transferred by a system of levers and springs to a hand which moves on a dial like that of a wheel barometer.

It is at once evident that the instrument must be graduated experimentally, as it cannot measure pressure absolutely, but affords indications relatively to a mercurial barometer (its sensibility depending, *inter alia*, on the quality of the metal of which the box is made).

The principle of the metallic (Bourdon's) barometer is somewhat similar to that of the aneroid.

Aneroids are very sensitive, but, unfortunately, they do not preserve their accuracy. If a table of corrections be determined for an aneroid, it will be found that after a time it has undergone some change, and that the values of the corrections will require alteration, so that recomparison with a standard barometer will be necessary. In every case of such comparison the readings of the mercurial barometer should be reduced to 32°.

A most serious objection to the scientific utility of these instruments is their liability to injury, owing

to rust or to the alteration of force in the springs used for their construction.

For concerted observations accurate mercurial barometers are indispensable.

In ascending altitudes the instrument is very useful; all that has to be done is to take the barometric reading at the bottom of the hill or mountain, and deduct from it the reading at the desired altitude. The difference, ignoring decimal points, multiplied by 9 will give the height in feet.*

5. **Winds.**—Winds, as we have seen, play an important part in the determination of climate, so that their study holds an important place in meteorological observations.

Their velocity and pressure is measured by anemometers.

Robinson's anemometer is the only one in general use.

It consists of four bars rotating horizontally round an axis connected by a mechanical contrivance with several recording dials. Each bar has fitted at right angles to its extremity a small cup.

The wind impinges on the cups at the end of the bars, and causes the apparatus to revolve round the axis.

The speed has a direct relation to the size of the cups and the velocity of the wind. In Negretti's latest instrument it is self-recording.

The position selected for the instrument should always be one which will secure the fullest exposure to wind from all quarters.

In many districts, and even in whole provinces, we have, as the result of intense heating of the surface, great heightening of the temperature of the

* Example: Reading at start = 31·00
,, desired height = 28·00

300 × 9 = 2,700 feet.

air near the soil, with the result that areas of low barometric pressure are created, to counteract which air converges from all sides, and takes on a circular motion round its centre. These are, in fact, miniature cyclones, and revolve in the opposite direction to the hands of a watch, the motion being not truly circular, but spiral, in such a manner that a particle carried by the wind, after circling round the centre several times, is ultimately carried to the centre of low pressure. After a period of exceptional heat and stifling calm, the still leaves of the dried-up trees are agitated by light puffs of air from various directions. Soon in the distance is seen a column of dust, and this steadily advances, bringing with it a violent fiery wind. When it has passed, and the air has again cleared, a refreshing relief of the previously intense heat is experienced. When of very small dimensions, these miniature cyclones are known as "devils," and their form, narrow below and spreading out like a funnel above, is very sharply defined. The boundaries of the expanded upper part are indistinct, and fade gradually into the steel grey of the surrounding glare ; but below the contour of the column is well-nigh as sharp as if it was composed of solid materials, and it may sweep close along by the observer without involving him. When of larger dimensions, so that the boundaries of the revolving column of dust and air are beyond the range of vision, they are known as "duststorms," and, in spite of the temporary discomforts they cause, are gladly welcomed on account of the relief they bring from the suffocating heat. From a sanitary point of view these storms are usually beneficial, as they clear and cool the air, but, of course, their effect is only temporary (Giles).

CHAPTER II

AIR AND VENTILATION

To understand the subject, it is necessary to know—

1. The constituents of the atmosphere.
2. The chief sources of its impurity.
3. The amount of air space necessary.
4. Nature's agents for purifying the air.
5. Our artificial means of supplying the individual with fresh air.
6. The dangers of impure air.

1. **The Constituents of the Air.**—*Constant :*

In one hundred volumes:

(1) Oxygen, 21 parts.
(2) Carbonic acid, CO_2, 0·04 parts.
(3) Nitrogen, including helium neon, krypton, and zenon, 78 parts.
(4) Argon, 0·9 parts.
(5) Water in gaseous form.

Occasional :

(1) Ozone.
(2) Ammonia.
(3) Marsh gas.
(4) Carbonic oxide.
(5) Sulphurous acid.
(6) Sulphuretted hydrogen.
(7) Nitric acid.

The Chief Sources of Impurity of the Air.—

(1) Products of respiration.
(2) Products of combustion.
(3) Products of decomposition.
(4) Dust.
(5) Bacteria.

(1) *Products of Respiration.*—Respiration adds to the air the following :

(*a*) Carbon dioxide.
(*b*) Water.
(*c*) Dead tissues.
(*d*) Bacteria.

The proportion of the last two added to the air varies greatly, but the quantity of carbon dioxide added is comparatively constant. In round numbers, 4 per cent. of oxygen is abstracted from the air in the lungs, whilst 4 per cent. of carbon dioxide is added to it.

Expired air is usually saturated with watery vapour, but the exact amount of water added varies with the degree of saturation which obtains in the air breathed.

As a round figure, it may be stated that about half a pint of watery vapour is given off by the human lungs, and about a pint by the skin, in twenty-four hours.

In health expired air contains few microbes, but much organic matter. This organic matter diffuses sluggishly through the air of a room, and is destroyed slowly by fresh air. It promotes the growth of micro-organisms, and rapidly taints milk, meat, and other foods, in contact with it.

The average adult gives off about half a cubic foot of carbon dioxide per hour, and oxen and horses about three times that amount.

It will readily be grasped from these figures how indescribably foul the air of tropical huts can become when half a dozen human beings and several animals are herded together in one small unventilated room in the still atmosphere of the equatorial belt.

(2) *Products of Combustion.*—The chief products of combustion are—(*a*) Carbon dioxide, (*b*) carbon

monoxide, (*c*) sulphur compounds, (*d*) water, and (*e*) fine particles of matter.

In the tropics fuel generally consists of wood, and kerosene oil is the chief illuminant. Burning wood yields few of the sulphur compounds, and oil scarcely any, but they increase the organic material in the air.

(3) *Products of Decomposition.*—The chief practical point in this connection is that decomposing vegetation produces the poisonous and inflammable gases H_2S and CH_4, so that the heaps of rotten leaves, etc., which are generally to be found outside a bedroom in the tropics are things to be avoided.

Sulphuretted hydrogen may occur in marshes, in and near excavations, in collections of refuse or decaying vegetable matter, and other waste heaps.

The inhalation of the gas is frequently followed by marked poisonous results. An atmosphere containing 1 part in 7,000 parts of air is dangerous to human life; whilst air containing 1 to 2 parts per thousand kills in a few minutes. When only minute quantities are present, giddiness, headache, and general depression, are produced.

(4) *Dust.*—This is a source of impurity of the greatest interest to us in the tropics. The following ingredients may be found by microscopical examination of ordinary bazaar dust:

(*a*) Fragments of charcoal.
(*b*) Fragments of cotton and other fabrics.
(*c*) Fragments of skin.
(*d*) Fragments of insects.
(*e*) Fragments of hay and straw.
(*f*) Dried sputum.
(*g*) Dried fragments of excrement.
(*h*) Bacteria anchored on to all these various particles of matter.

The harmless-looking motes which we see dancing in the sunshine are, therefore, very frequently as

dangerous as cordite, and constitute not only an undesirable, but a positively disgusting, mixture.

Rooms should therefore be constructed so as to facilitate the removal of dust.

A few lessons in the use of a damp cloth for dusting, or on the value of wet sawdust or tea-leaves before sweeping out rooms, would be a useful addition to the elementary education of tropical scholars.

(5) *Bacteria in Air.* — Bacteria in air vary in number and species, according to certain external conditions, such as the pollution of the air, the dampness of surrounding surfaces, gravity, and various seasonal and climatic conditions.

Tyndall first pointed out that dust might carry microbes, and that, other things being equal, dusty air contained more bacteria than dust-free air. Haldane and others have confirmed this statement by the examination of air from numerous sources. In the open jungle, on mountain-tops, and at sea, few bacteria are present ; but in the crowded Indian bazaars they abound in countless myriads. Miquel found an average of 455 bacteria per cubic metre in a French park, an average of 3,910 in the chief street of Paris, and 79,000 in a hospital ward. A polluted or dusty atmosphere generally contains many bacteria and much carbonic acid, but there seems to be no direct relation between them. An atmosphere may be offensive, and yet comparatively free from bacteria, as in the case of sewer gas and railway tunnels. The presence or absence of an offensive odour, therefore, must not be regarded as a criterion of the purity of the atmosphere.

Air over sandy soil contains more bacteria, as a rule, than that over damp clay soils. Rain also diminishes the number of organisms in the air. It has also been proved that air saturated with moisture is almost germ-free. Hence the comparative absence

of bacteria in expired air in ordinary quiet respiration, though in the act of coughing, sneezing, or shouting, organisms may be present. The same principle applies in sewers, the air of which frequently contains fewer organisms than that of outside air. This is also the explanation of the retention of the tubercle bacillus in sputum, and the typhoid bacillus in dejecta, when these materials remain moist.

The influence of gravity operates upon microorganisms in the same way as upon other matter. Hence fewer bacteria are found at high altitudes or on the tops of lofty buildings. For instance, it has been found that at the top of the Clock Tower of the Houses of Parliament in London there was only one-third of the number of bacteria found at ground-level.

The seasonal maximum in the open air seems to occur about midsummer, and the minimum about the middle of winter ; but in hospital wards and houses the reverse occurs. Air currents and winds, and of course rain, exert a marked influence. Sunlight, especially in tropical lands, possesses great germicidal powers, and is a potent agent in reducing the number of air organisms.

The number of microbes in the air of *crowded rooms* is dependent more upon habitual ventilation and cleanliness than upon the conditions at the time of observations. They are not due to respiration; and whilst many may be due to uncleanly persons or clothing, they are mainly derived from the walls, ceiling, and floor, of the room itself, especially if these are porous and absorbent, as most rooms in the tropics are. The variety of microbes found in the air is considerable, and for the most part they are harmless to man ; but they may include putrefactive, suppurative, and intestinal organisms and the specific

germs of disease. The bacilli of tubercle, typhoid fever, and other diseases, have under favourable conditions been isolated from air, and Gordon has deseribed an "air streptoeoeeus" and a "skin staphyloeoeeus," always assoeiated with filth and human pollution (Whitelegge).

Spores of moulds and pollen may also be found, and may be the source of sueh diseases as hay fever.

3. **The Amount of Air Space necessary.**—This will depend on the purpose for whieh the room is to be used. More spaee is, for instance, required in a faetory than in a dwelling-plaee.

For ordinary living-rooms—in Europe, at least—1,000 eubie feet of spaee is allowed for eaeh person oeeupying the room—*i.e.*, a spaee 10 feet long, 10 feet wide, and 10 feet high. In calculating the eubie spaee of a room, the cubie spaee oeeupied by furniture must be deducted, and an allowanee must be made for the number of lamps generally used. The more lamps used, the larger must be the eubic spaee allowed for eaeh person ordinarily oceupying the room, and it may be taken as a rough average that every kerosene-oil lamp burning in a room pollutes the air to the same extent as seven adults.

In buildings whieh are only oecasionally used, sueh as churehes, theatres, sehoolrooms, and the like, it is generally quite impossible to allow suffieient cubie spaee for the large number of persons assembling there. To make up for this, ventilation should be as free as possible. In hospitals a much larger eubie spaee and the freest ventilation are partieularly neeessary. In faetories, shops, and offiees, particular attention must be given to providing as mueh eubie spaee and free ventilation as possible.

The Faetory and Workshops Acts of 1901 and 1907, which are, of eourse, not applieable outside the United Kingdom, enaet that there must be at least

250 cubic feet of air space for each worker. The air space of each room must be stated in a notice affixed in the works.

A much larger air space is required in certain dangerous trades; *e.g.*, in match factories in which yellow phosphorus is used, the minimum is 400 cubic feet, and height above 14 feet is not to be counted; and in engineering works exemption from routine annual limewashing is allowed if the air space be 2,500 cubic feet per head (Whitelegge).

For general purposes of ventilation all height of rooms above 10 feet may be disregarded, but in the tropics the height from floor to roof should be 15 feet or more, for reasons to be indicated later. This extra height must not, however, lead to any reduction in the amount of floor space. One thousand cubic feet of fresh air contains 0·4 cubic foot of carbonic acid, and a man gives off 0·6 cubic foot of CO_2 per hour; he therefore requires 3,000 cubic feet of air per hour to maintain the recognized standard of purity of 0·06 per cent. of CO_2 in air.

For instance, if six people are living in a room, to give the space recommended in Europe it would require to be 30 feet long, 20 feet broad, and 15 feet high, and the air would have to be changed thrice every hour if the CO_2 was to be maintained at the health limit.

In native houses in the tropics accommodation to this extent is utterly out of the question, so, fortunately, it is possible in a damp, warm climate to change the air oftener than three times every hour. For a room containing 500 cubic feet of space for every person living in it, it is necessary to renew the air six times every hour. In cold climates, such as that of England, or of India in the cold season, this is difficult to do, as it is found that if the air is changed more than thrice an hour the room becomes too cold

and draughty, and people are apt to "catch cold" and get ill; but in most parts of the tropics the "draughts" produced by the free perflation of air necessary to attain the amount of air change necessary have no prejudicial effects whatever.

4. **Nature's Agents for Purifying the Air.**—These are—

(1) Rain.
(2) The action of sunlight.
(3) The action of plants.
(4) Winds.
(5) Diffusion of gases.
(6) Difference of temperature.

(1) *Rain.*—Rain is simply a mechanical purifier; it washes the air. As it falls it removes all suspended organic impurities, and absorbs some of its harmful gases.

(2) *The Action of Sunlight.*—Sunlight has the power of killing germs in the air.

(3) *The Action of Plants.*—Plants absorb carbonic acid from the air, and give off oxygen.

(4) *Winds.*—The winds tend to distribute the air, and thus, by mixing the gases, produce uniformity of composition. They are powerful ventilating agents.

(5) *Diffusion of Gases.*—All gases tend to mix with one another, in accordance with Graham's law that the diffusibility of any two gases varies inversely as the square root of their density.

The atmosphere, being a mechanical mixture of gases, is subject to this law, and tends, therefore, to uniformity of composition. The gases, vapours, and animal impurities, breathed out by animals mix readily with the air, and are diluted, and the more air they are mixed with the less harmful they are.

(6) *Differences of Temperature in Air.*—Warm air is lighter than cold; therefore it ascends, and is replaced by the heavier cold air. The warm air and

bad gases in an inhabited room ascend toward the ceiling. If there is an opening at the top of the room, the foul air goes out by it, and it is thus got rid of. If there is no such opening, however, the bad air gets cooler, becomes heavy, and descends, and the inhabitants are obliged to inhale it once more. It follows, then, that all houses should have openings in the upper part of the room to let out the foul air. In India exit of foul air is best assured by having small windows placed near the roof.

Under this heading comes *Natural Ventilation.* This is effected by the last three agents—viz.: (*a*) winds, (*b*) diffusion of gases, and (*c*) differences in temperature.

(*a*) *Winds.*—Ventilation by perflation, or "flowing through," is the chief means of ventilation in the tropics. Houses should have windows and doors nearly facing one another.

Perflation, however, cannot alone be exclusively relied on, as the winds change very frequently.

In most better-class tropical houses there are so many doors and windows that there is no risk of bad ventilation if they are left open. The covering of doors and windows with *chics* or *jhilmils* to keep out glare, heal, flies, etc., need not interfere seriously with the ventilation.

In hot weather windows and doors should all be left open at night. In the day-time air finds its way in through the *chics* covering the doors.

(*b*) *Diffusion of Gases.*—Punkahs and electric fans do not increase the purity of the air. They only move the air in the room, and do not to any extent draw in the outside pure air or drive foul air out of the room.

In hot weather there is often little difference between the temperature of the air inside and outside of the house, and so there will be little or no exchange of

air going on. It is, thus, all the more necessary that the rooms should be large and that the doors and windows should be left open as much as possible. The difficulty is that by the latter procedure the hot outside air enters the rooms, but *khus-khus* tatties* will cool it where the air is dry or hot winds frequent. In moderately hot weather doors and windows should be left open night and day, as much as possible. The heat will do far less harm than breathing poisonous air.

The huts of the poorer classes are generally very badly ventilated. There are no outlets for smoke or foul air, and, where they exist, they are usually tightly closed up in the colder season.

(*c*) *Differences of Temperature of Pure and Foul Air.*—As hot air ascends, a space for ventilation along the topmost ridge of the roof—the so-called "ridge ventilation"—should be provided, or a space left between the top of the walls and the roof.

The latter is a favourite device for securing this method of natural ventilation in Indian barracks.

A staircase should be well ventilated by a large rainproof opening in the roof, as the staircase not only receives foul air from the rooms, but feeds them with air.

5. **Artificial Means of Supplying the Individual with Fresh Air.**—This embraces the method of artificial ventilation. This falls under two headings, viz.:

(1) The *plenum* method, in which fresh air is driven into rooms by revolving fans.

(2) The *vacuum* method, in which foul air is extracted by heated outlet shafts, steam-jets, or fans.

Heat is the motive power generally used for extraction.

Ordinary fireplaces, chimneys, and ventilating gaslights, are familiar examples of the latter method.

* *Vide* Chapter VI., p. 86.

A variety of *plenum* method is familiar in India in the form of an artificial ventilator, known as the "thermantidote." It propels a stream of fresh cooled air into the room, and thus cools and ventilates it. The apparatus must be used so that no draught or current of air from it is felt, and, where possible, it should be placed in a room opening out of the room in use, and the cool air thus allowed to gradually mix with that of the room which is being occupied.

6. **Dangers of Impure Air.**—Crowding in a common atmosphere has long been known to be disastrous in typhus, erysipelas, diphtheria, influenza, and other maladies, both as regards transmission of infection, intensification of type, and retardation of recovery. Ventilation has greatly lessened phthisis in barracks and other institutions, and with cleanliness it has banished typhus from prisons, and hospital gangrene and erysipelas from hospitals. The success of the open-air treatment in sanatoria for phthisis has the same significance. It is evident that all diseases in which the breath is infectious must be more readily transmissible when the expired air is rebreathed in a concentrated form (Whitelegge).

There is abundant evidence of the gain in comfort, general health, and longevity, under conditions of adequate fresh-air supply, and, conversely, of much disability from sickness of all kinds, and high death-rates, amongst those whose lives are largely spent in ill-ventilated rooms.

The feeble health of the tropical resident is largely due to the way in which he shuts himself up in small unventilated rooms, and then covers his face up with a sheet or blanket.

CHAPTER III

WATER AND WATER-SUPPLIES IN THE TROPICS

THE amount of water or other liquids required by man, over and above what he obtains in his food, is about 2 pints in temperate climates, but in the tropics a very much larger quantity is consumed by most people.

Man requires water for many purposes, and the quantity which he uses varies with the locality.

In places like Calcutta and Peshawar, the daily allowance per head is as much as 41½ gallons of filtered water; but in many tropical towns, villages, and even military cantonments, scarcity of water constitutes a hardship.

Pure water for drinking purposes is not easy to obtain in the tropics. The reason for this difficulty is mainly due to the pollution to which the water is subjected by the customs of the people, and it is largely owing to this pollution that diseases caused by microbes and parasites are so rife. In warm climates, disease germs and parasites exist in water in far greater variety and numbers than in the temperate zone, where the conditions are not so favourable to their growth and development. The drinking of impure and muddy water in a cool climate is liable to produce enteric fever, diarrhœa, and possibly worms; but the drinking of similar water in the tropics is not only liable to produce these diseases, but also cholera, dysentery, goitre, and many other

parasitic affections. In hot climates, even the external use of bad water for bathing purposes may cause Oriental sores, Guinea worms, and other maladies.

All the world over, man derives his water-supply directly or indirectly from the rainfall. Water as it condenses in the clouds from the gaseous state is absolutely pure, but by the time that it reaches the surface of the earth in the form of rain it has become impure. Rain, as we have seen, is a purifier of the air, and in performing this service to man it becomes itself impure. It washes various undesirable gases and obnoxious solids, in the form of dust, out of the air, and either sinks into the soil or flows along its surface in streams.

Tropical like temperate water-supplies are obtained from six sources, which, according to their origin, are known as—

1. Upland surface water—*i.e.*, water running down hills in small streams to natural or artificially-made lakes.
2. Rain water.
3. Ordinary surface water from cultivated land, such as land springs, streams, and ponds.
4. River water.
5. Ground water from wells and springs.
6. Distilled water.

Comparison of Waters derived from Different Sources.

The Rivers Pollution Commissioners classify the qualities of these waters as follows :

In respect of wholesomeness, palatability, and general fitness for drinking and cooking—

1. Wholesome	(*a*) Spring water. (*b*) Deep well water.	Very palatable.
2. Suspicious	(*c*) Upland surface water. (*d*) Stored rain water.	Moderately palatable.
3. Dangerous	(*e*) Ordinary surface water from cultivated land. (*f*) River water to which sewage water gains access. (*g*) Shallow well water	Palatable.

In respect to softness they grade them as follows :

(*a*) Rain water.
(*b*) Upland surface water.
(*c*) Surface water from cultivated lands.
(*d*) Polluted river water.
(*e*) Spring water.
(*f*) Deep well water.
(*g*) Shallow well water.

From the above it will be seen that the comparatively hard waters, derived from springs, and deep wells, are the safest for drinking purposes, and the interests of the trading community are thus evidently opposed to those of the householder.

1. **Upland Surface Waters.**—A great number of places in the tropics obtain their supply from sources of this kind, which are generally good ones, as highland districts are usually sparsely populated, and the land is accordingly poorly cultivated, so that the risk of sewage contamination is slight.

2. **Rain Water.**—As a source of supply, rain largely concerns us in the tropics, as in places where the rainfall is heavy and the springs are brackish it forms our chief stand-by.

In warm countries, where the duststorms referred to in Chapter I. are frequent, the roofs of houses are generally polluted with animal matter from the excrement of birds, dust from the roads, and the eggs of insects. These pollutions washed into tanks give the water an unpleasant taste, and in some instances cause disease. It is desirable, therefore, that as far as possible impurities from the roof shall be prevented from gaining access to the tank. With this object, contrivances have been made which reject the first washings off the roof, and afterwards direct the flow into the storage tanks.

Roberts' separator is one of the most ingenious of these machines. It is constructed in sizes which bear a certain ratio to the superficies of the roof area, and is so arranged that, when a sufficient amount of rain has fallen to cleanse the roof, the water first collected is tilted into a waste channel, and the remainder directed into the collecting channel and reservoir.

The same inventor has devised an apparatus whereby pure water may be obtained from the roofs of cottages and houses too small for the use of the separator. The dirty water which first comes from the roof during a spell of rain is rejected, whilst the clean water which falls later is directed into a storage tank, thus preventing any mixture of the clean and unclean water.

3. **Ordinary Surface Water.**—This must always be regarded as dangerous, as the presence of sewage is wellnigh certain. Ponds and tanks constitute a particularly dangerous source of water-supply, which, unfortunately, is the only one obtainable in many parts of the tropics.

4. **River Waters.**—Such waters are constantly liable to pollution by men and animals. If it were not for the beneficent purifying work of oxygen.

rivers in the tropics would soon become little more than open sewers; but, fortunately, purifying processes go on actively in river water, and, if the stream has many falls and eddies, the amount of oxygen dissolved in the water is so great that a moderate amount of contamination is soon got rid of. Moreover, there are various green river plants continually at work giving off oxygen in most active condition.

The oxidation process in rivers is started by bright sunlight, and when the stream becomes thick or muddy this process is checked or stopped; but even when this occurs, there is still a purifying action going on, as a number of fish, shellfish, crayfish, small animalcule microscopic plants, and bacteria, live on sewage or other organic débris. Unfortunately, these purifying processes in most rivers are not sufficient to cope with the quantity of dead organic material constantly poured in from source to mouth. The value of fish as purifying agents of water is so well known as to require merely a passing reference.

5. **Ground Waters.**—The water which falls on the earth and sinks into the soil returns again for the use of man as (1) wells and (2) springs.

(1) Wells.—To understand the condition of tropical wells, it must be understood that land in the neighbourhood of villages and towns in the tropics is polluted with human excrement to a degree which is almost incredible to anyone who is not conversant with Oriental conditions. Latrines may be constructed, but practically the whole of the male and some part of the female population prefer to go into the neighbouring fields rather than to make use of them. It is only in large cities, where fields are at considerable distance from the houses, that latrines are used to any extent, and even then a fair proportion of the inhabitants, particularly children,

simply make use of pieces of waste land and lanes in the midst of houses. The fæcal discharges deposited in this manner are not buried in the manner customary amongst the Jews, but simply left to the drying action of the sun and hot winds. Naturally, in rainy weather it is washed into the soil, if the latter be of a sufficiently porous nature, and yet the entire population living under these conditions almost invariably derives its water-supply from shallow wells.

Wells are divided into three varieties: (*a*) Shallow, (*b*) Deep, and (*c*) Artesian. The descriptive words are not used to indicate the relative depth of the wells, but to describe the water-bearing strata they tap. All shallow wells must be regarded as suspicious sources of supply, and none of them can be looked upon as safe. The sanitary officer would be ill-advised to sanction the use of any well water on the mere ground of satisfactory laboratory analysis. At any moment pollution may occur after the passed sample has been collected, so that the analysis becomes utterly valueless as a sanitary guide.

(*a*) *Shallow Wells.*—Shallow wells are those which are sunk in pervious soils, and tap the underground water which has percolated from the surface within its immediate vicinity.

In the large majority of cases where shallow wells yield polluted water, this is due to defects in the construction of the wells.

The water which enters a well at a depth of 6 to 12 feet, according to the porosity of the soil, is usually efficiently filtered and purified. Water entering at a less depth is always liable to be imperfectly purified and unsatisfactory in quality. The nearer the ground surface at which water can enter, the greater the danger of pollution.

It follows, therefore, that the upper 6 to 12 feet of the well should be water-tight, and that the top

should be so finished off that no surface water can possibly gain access. The top of the well should be brought up about a foot above the ground surface, and covered with a well-fitting iron cover. Wooden covers warp and soon become useless in the tropics.

The area surrounding all wells should be concreted and provided with a water channel.

Pumps should always be provided, as dipping of buckets provides endless facilities for contamination.

A radius of 100 yards should invariably be left clear round all wells.

(*b*) *Deep Wells*.—These are wells which, passing through both the pervious surface layer and an underlying impervious stratum, tap water which has percolated from the land surface at some distance from the shaft. They are good sources of supply, but, unfortunately, comparatively rare in the tropics, as their construction is expensive.

(*c*) *Artesian Wells*.—Artesian or tube wells are far better than dug wells. They consist of iron tubes hammered into the ground until water is reached. Like all other wells, they must be adequately protected at the surface to prevent pollution at that point.

(2) Springs.—These are generally described as land and main springs. Land springs are often due to surface depressions touching the underground water-level. When the underground water reaches its lowest level, such springs run dry.

Manifestly, they receive their supply from very near the surface, and so are extremely liable to organic pollution.

The classification of all springs as wholesome by the Rivers Pollution Commission is therefore misleading.

Main springs are, however, generally good, as they act as the main outlets for geological strata; but occasionally they, too, are doubtful sources of supply,

and great care is necessary to investigate their immediate neighbourhood for surface-derived impurities.

6. **Distilled Water.**—This is the means of supply to the troops and residents in rainless tracts, such as Aden, and in regions where the rainfall is scanty or where there are only salt lakes.

Distilled water is also used on board ship when the ordinary shore supply runs out.

Distilled water is flat and unpalatable, so that its efficient aeration is an important consideration and should form a part of the plant for providing it on a large scale. For ordinary purposes it may be aerated by half filling an ordinary wine-bottle with the water, and then vigorously shaking, so as to cause the air to be absorbed by the water.

Pollution of Water-Supplies.

This may occur—

1. At their source.
2. During storage.
3. During transit or distribution.

1. **Pollution at the Source.**—Every effort must be made to prevent any form of pollution in the neighbourhood of the wells, springs, or tanks, from which drinking water is obtained. The question of the protection of "catchment areas" is one of the first importance to Governments and municipalities in the tropics.

In many places in the tropics it is a common practice to bathe in the tank from which the drinking water is taken, also to spit and wash the mouth in the tank or stream used for drinking purposes. The residents then collect the water quite close to the place they have just polluted, for their cooking and drinking supply for the day.

2. **Pollution during Storage.**—Drinking water should not be stored at all during cold weather, unless the

procedure is absolutely unavoidable ; but in the hot season some simple means of storage for the purpose of cooling becomes an imperative necessity.

There is no doubt that the compulsory storage of water for the purpose of cooling it during the hot weather is a fruitful source of pollution, and too much attention cannot be paid to it.

The ordinary Indian *surai* certainly cools water, but it has the disadvantage of being difficult to clean. Moreover, it is readily passed from mouth to mouth, and is not always kept covered.

Water should be stored in glazed vessels, and these should always be kept perfectly clean and cool. Metal vessels may also be used for drinking waters, as they can be kept clean. The brass and copper *lotahs* which are in general use in the East amongst Hindus may subserve to keep the water pure, as recent experiments indicate that iron and copper in minute quantities inhibit the growth of pathogenic organisms.

The reason that glazed and not unglazed *chatties** should be used is that the latter take up dirt of all kinds by their pores, whilst in the former these pores are filled up, and so cannot absorb dangerous substances. The smooth glazed surface is also much more easily kept clean than the unglazed.

Galvanized iron or slate cisterns are the best means of storage on a large scale, but they are usually impracticable for tropical houses on account of expense. For storing small quantities of drinking water, clean glass bottles with air-tight glass stoppers, such as those in which pasteurized milk is issued, are best for use in houses, but they are costly.

All vessels used for storing water must be kept covered, so as to prevent dirt and dust from falling into the water.

* Earthern pots.

3. **Pollution during Transit.**—This is another very common source of infection.

The transport of drinking water to the house is an important matter in the tropics, as even in large towns provided with modern waterworks it is only the few better-class residents who can afford pipes to their houses. The best pipe supply is usually only a street distribution. In India the water-carriers employ for the conveyance of water what is called a *mashak*, which consists of the entire skin of a sheep or goat roughly cured and carried slung across the back. This mode of transport in a leathern vessel, which cannot be kept clean, is sure to contaminate the water, however pure the source from which it is taken.

The Purification of Water.

In most tropical countries we have to start with the idea that the water is bad, and endeavour to remedy the defects of the natural supply as best we can.

It often happens that, owing to a deficiency in the amount of pure water available, a town is provided with two supplies—a pure water for drinking, and a less pure water for washing, trade, and municipal purposes. This is the case to some extent even in large Continental towns, such as Paris. There are circumstances, of course, in which this plan is unavoidable, but as a principle it is a bad one; for it frequently happens that the impure water is used for drinking purposes, and in this way epidemic disease is spread.

Broadly speaking, there are three methods for rendering impure water innocuous :

1. Physical. { (*a*) By distillation. (*b*) By boiling.
2. Mechanical : By filtration.
3. Chemical { (*a*) By precipitation. (*b*) By use of germicides.

1. **Physical.**—(*a*) Distillation is, as we have seen, the chief means of supplying drinking water at Aden and in other rainless regions. (*b*) Boiling presents one of our oldest and best methods of preventing the noxious effects of bad water. Combined with some simple form of clarification or filtration, if fuel is available, it is the readiest method of dealing with impure water.

Its disadvantages are—

(1) It is expensive, because fuel is required.
(2) The water becomes insipid.
(3) The water is heated, and must be cooled before use.

The first of the disadvantages is vastly the most important. The remaining two can be got over by aerating the water in the way already described, and by storing it in tightly corked bottles in an ice-chest.

2. **Mechanical.**—Purification of water on a large scale is necessary in all water derived from catchment areas containing arable land, and from rivers. It is effected by—(*a*) Sedimentation, (*b*) filtration.

(*a*) *Sedimentation* is effected by storing the water in a large reservoir. The action of gravity causes suspended matter, coarse and fine, to fall to the bottom, carrying with it a large proportion of the micro-organisms present in the water. In the term "sedimentation" is generally included the effects of sunlight, for the diminution in numbers of micro-organisms per cubic centimetre which follows sedimentation must be largely due to the operation of the germicidal properties of sunlight. The best results are obtained when the flow of water in a reservoir is sufficient to prevent stagnation, and at the same time to enable gravity to operate. Under such conditions the average number of microbes is reduced

from 16,000 per cubic centimetre to numbers varying from 1,000 to 7,800.

(*b*) *Filtration* of some kind or other is a method which has existed from time immemorial, as the ancient Hindu laws directed that water should be drunk only after filtering through cloth.* This recognizes the necessity for purifying water, though the method is, of course, useless. Even of the crudest nature, filtration always improves the potability of a water, and a simple device, such as barrels fitted one inside the other, with a good layer of gravel, sand, and wood ashes, between them, will not only clarify, but actually purify, water very considerably.

Filtration of water may be by—(1) Public filtration; (2) domestic filtration.

(1) PUBLIC FILTRATION. — The principal public filters in use are—(*a*) Sand filters; (*b*) Coagulant filters; (*c*) Anderson's filter.

(*a*) *Sand Filters.*—Sand filters are composed, from above downwards, of (1) a layer of sharp sand 3 feet in depth; (2) a layer of gravel or broken shell 6 inches in depth; (3) 6 inches of small boulders, large gravel, or bricks. The efficiency of filtration does not depend so much upon the total depth or composition of the filter-bed, as upon the rate of filtration and the formation of a zooglœa mass on the surface of the sand. In London the depth of the water on the filter-bed does not exceed 2 feet, and the rate of filtration is about 1½ gallons per square foot per hour, or 36 to 42 gallons in twenty-four hours. The efficiency of sand filtration may be gathered from the fact that the number of organisms per cubic centimetre is reduced from 16,000 in crude Thames water to numbers varying between 35 and 100.

* Manu directed that water should be drunk only after filtering through cloth. The Susruta give rules for purifying water by boiling and filtration.

Koch has laid down the principle that no water should be permitted to enter a service reservoir which contains more than 100 organisms per cubic centimetre, and the experiments of the Massachusetts Board of Health prove that filtration removes fully 99 per cent. of organisms, provided the sand filter-bed is 60 inches in depth, and the rate of filtration does not exceed 2,000,000 gallons per acre per day.

The highest point of efficiency of a filter-bed is not obtained until at least five days after it has commenced working, the operation being much more than a mere mechanical straining operation. The thin gelatinous film, consisting of organic matter and bacteria, which forms on the surface, acts as a biological filter arresting micro-organisms.

The life of a filter-bed depends upon the character of the water to be filtered; at Peshawar, on the Indian frontier, where a very crude river water is dealt with, it is eight days. At the end of this time the filter-bed is allowed to run dry; 2 inches of sand on the top are removed, and replaced by clean sand.

(*b*) *Coagulant Filters.*—Of late years ordinary sand filtration has been found too slow for rapidly expanding communities, and has been replaced in several hundred places by apparatus based on the principle of mechanically filtering a mixture of the water and some coagulant at high velocity through sand. The Jewell filter, which is the best known of these special filters, may be described as follows—(*a*) *Mixing Tank:* In this the coagulant, which consists of a 2 per cent. solution of sulphate of alumina, is added to the raw water. The water mixed with the alumina passes to (*b*) the *Subsidence Tank.* The use of the coagulant results in the forming of a flaky, jelly-like substance, which carries with it to the bottom of the subsidence tank the greater bulk of suspended matter. In Alexandria, Egypt,

where the Jewell filters are used, it has been found that by adopting a six-hour period of subsidence 75 per cent. of micro-organisms are removed. After subsidence the water passes to (*c*) the *Filter proper*, which consists of a steel cylinder, open above and closed below. Inside the true bottom of the cylinder there is a false bottom, on which is laid the filtering material, which consists of a layer of gravel covered with about 40 inches of sand. The upper part of the cylinder is double, enclosing a circular space into which the water passes; it flows over the lip of the interior cylinder, and thence through the filter-bed to the exit pipe.

The action of the filter is both chemical and mechanical. If the water contains carbonate of lime, the chemical reaction which takes place is as follows:

$$Al_2(SO_4)_3 + 3CaCO_3 + 3H_2O = Al_2(OH)_6 + 3CO_2 + 3CaSO_4.$$

The hydrate of alumina formed entangles within its flaky, jelly-like substance minute material of all kinds. Most of this subsides by gravity in the subsidence tank, and any which remains in suspension is arrested in the upper layers of the filter-bed, thus forming a scum not unlike the biological scum formed in ordinary sand filtration, and having a precisely similar action.

The Jewell filters in use in Egypt are reported to reduce the number of organisms per cubic centimetre from 700 to 4,700 in the raw water to from 9 to 27 in the filtered water.

In addition to the Jewell pattern, other varieties of rapid filters are on the market, notably Bell's, in which the beds in the filter chambers are composed of silver sand. In the Edinburgh installation each filter is able to deal with from 6,000 to 10,000 gallons per hour.

(*c*) *Anderson's Revolving Purifier.*—This apparatus

consists of a revolving cylinder containing a quantity of scrap iron; the water to be purified is passed through the cylinder, which, as it slowly revolves, brings it in constant and violent contact with the pieces of iron. In consequence the water takes up from $\frac{1}{10}$ to $\frac{1}{5}$ of a grain of iron oxide per gallon. By causing the effluent water to flow along shallow open troughs, this oxide is thrown out of solution, and the treated water is then allowed to deposit in sedimentation reservoirs. The effect of the process is to rid the water of about 63 per cent. of organic matter, and to reduce the number of micro-organisms from 800 to over 7,000 per cubic centimetre to about 40 per cubic centimetre.

(2) Domestic Filtration.—Filtration on a small scale for domestic purposes is now usually effected by two kinds of filters—the Pasteur-Chamberland and the Berkefeld.

The older varieties of filters, constructed of charcoal, asbestos, spongy iron, and polarite, have now practically disappeared in the tropics.

The disadvantage of the Pasteur filter is that a considerable amount of pressure is required before water can be obtained in any quantity. Ordinary river water in the tropics is usually very turbid, so that it rapidly clogs the filter candles, with the result that water ceases to pass. It is now fully recognized that no filters of this type can be of general utility in the tropics, unless they are worked in connection with a clarifying apparatus.

3. **Chemical**—(1) Mechanical.—Alum and lime are used as merely mechanical purifiers; they have no specific action on the water. They simply form a precipitate which falls to the bottom, carrying with it most of the microbes and the organic impurities.

(2) Germicidal. — The germicides used are—(*a*) Permanganate of potassium; (*b*) the halogens;

(*c*) acid sulphate of soda; (*d*) ozone; (*e*) the ultra violet rays.

(*a*) In times of cholera the addition of *permanganate* to all water supplies has been recommended. No precise quantity is stated, the rule being merely to make the water pink for half an hour or so. The results are declared to be "most satisfactory, cholera-tainted sources of water-supply being made relatively safe."

The rationale of this procedure is utterly incomprehensible, and it is only mentioned to be condemned.

(*b*) *The Halogens.*—Bromide, chlorine, and iodine, have all been used with success to sterilize water.

(i.) *Bromine.*—Bromine has been used successfully by Schumberg, who adds ·06 c.c. of free bromine from a glass capsule to each litre of water. The smell and taste of the bromine is removed by adding tablets of sodium sulphite and carbonate.

(ii.) *Chlorine.*—This element has been used in a variety of ways for purifying water.

One of the simplest methods of treating a doubtful water is to add chloride of lime to it in the following way:

Add a drachm of chlorinated lime to a pint of water. Use this as a stock solution, and add 1 teaspoonful to 2 gallons of water, and stir thoroughly. Allow to stand for an hour, and then decant off the clear water. This simple procedure has been found most efficient in treating quite impure samples of water.

Chlorine has been used for the treatment of public water-supplies by means of an apparatus which consists of a vertical cylinder capable of holding 7,000 gallons. The water enters at the top of the cylinder, and leaves at the base. The mixture of bleaching-powder is pumped in measured quantities into the water, which by a system of baffle plates is retained in the cylinder for an hour. In the earlier experiments, neutralization of the chlorine was

effected by the addition of a small quantity of bisulphate of soda, which was introduced as the water was leaving the sterilizing chamber. It was found, however, that when the chlorination was properly carried out—*i.e.*, when sufficient, but no excess, of chlorinated lime was added this addition of bisulphate of soda was unnecessary.

The water as it leaves the cylinder flows into a galvanized iron tank and over a slotted weir, so graduated that the amount of water flowing at any given time may easily be measured.

In experiments conducted by Professor Sims Woodhead, in which 1 part of chlorine was added to from 1,000,000 to 4,000,000 parts of water, no *B. coli* or any of its congeners were found in from 150 to 500 c.c.

The amount of chlorine remaining at the end of the period of contact may be readily measured by the following simple test, which can be carried out by an intelligent layman: Add a crystal of iodide of potassium, a few drops of acetic acid, and a tablespoonful of starch solution, to a litre of the treated water in a glass jug held over a sheet of white paper. If a blue tint appears, too much chlorine is being added. A violet tint is the proper "end reaction," showing the presence of a trace of chlorine. If the water remains uncoloured, the amount of chlorine present is probably insufficient to insure sterilization.

(iii.) *Iodine*.—The best known method is that of Vaillard, which involves the use of three tablets: one red, containing tartaric acid and fuchsin; one blue, containing iodide of potash and iodate of soda and methylene blue; and a third, consisting of hyposulphite of soda. The red and blue are added simultaneously, and the white after ten minutes.

Iodine is liberated by the first two tablets, and neutralized by the hyposulphite of soda, as the free iodine combines with it, forming iodide of sodium.

The treated water is normal in appearance and free from taste or smell.

This treatment can be carried out in any metal vessel without detriment. In the case of water heavily laden with suspended matters, a preliminary clarification is desirable.

(*c*) *Acid Sulphate of Soda.*—This method depends on the liberation of free sulphuric acid from tablets containing 15 grains of acid sulphate of soda. They have been placed on the market at cheap rates by several firms. The tablets readily deliquesce if not preserved in accurately stoppered bottles. The free acid is very destructive, and the process can only be carried out in glass, earthenware, or enamelled vessels.

One tablet dissolved in a pint of water destroys all organisms of the *coli* group after half an hour's action.

The tablets on the market contain $\frac{1}{6}$ grain of saccharin and $\frac{1}{20}$ drop of oil of lemon in each.

The solution tastes something like weak lemonade. We have tried it on a large scale, and after two or three days' use *as an exclusive beverage* the mawkish flavour becomes very distasteful.

(*d*) *Ozone.*—The sterilization of water by ozone is largely used in France and Germany. Ozonized air furnishes a practicable and effective means of destroying all micro-organisms. It has been demonstrated, in the case of several important works on the Continent, that the use of ozone is not costly, while tests conducted on a large scale in the United States, at Philadelphia and elsewhere, have proved that this process can be depended upon to remove all germs and render water sterile. The adoption of a preliminary filtering process is, however, almost, if not absolutely, a necessity where ozone treatment is contemplated, so that this method is hardly likely

to find favour with Governments or municipalities in the tropics.

(*e*) *Ultra-Violet Rays.*—Much attention has lately been directed in France to apparatus for subjecting large volumes of water to ultra-violet rays for the purpose of purification. It has been assumed that the beneficent action of the sunlight in purifying water-supplies is due to the ultra-violet rays which are present in it in great abundance.

So recently as five years ago De Mare secured the first patent for an apparatus the essential feature of which was the immersion of a mercury vapour quartz lamp producing ultra violet-rays in a current of water.

Results have been published by various investigators demonstrating the very rapid effect on bacilli of exposure to the rays of a Westinghouse silica lamp, at distances varying from a few inches up to 2 feet. Some organisms are more resistant than others. For instance, *B. coli* succumbs in fifteen to twenty seconds, whilst *B. subtilis* needs thirty to sixty seconds' exposure at the same distance.

A further development in the use of the rays has been introduced by Dr. Billon-Daguerre, who has devised an improved mercury lamp with a projecting quartz shield, within which the lamp is fixed *in vacuo*. He claims that in this form of lamp the whole of the electric energy is transformed into ultra-violet rays. It is stated that, after treatment with a 4·5 ampère lamp at 100 volts, water which originally contained 2,000 colonies per cubic centimetre, contained only 0·3 colonies in the same quantity.

CHAPTER IV

FOOD AND FEEDING

THE foodstuffs used in various parts of the world are legion, but all the important constituents of them fall under one of the following five headings :

1. Nitrogenous compounds, or proteins.
2. Fats.
3. Carbohydrates, including sugars, starches, and various kinds of vegetable foods.
4. Salts.
5. Water.

In addition to these five essentials, there is an important group of articles, such as tea, coffee, and condiments, which are known under the comprehensive title of food accessories.

Each of these five groups has more or less specialized functions, which may be stated as follows :

1. **Proteins.**—The functions of nitrogenous foods are fourfold, viz. :

(1) To build up the tissues and repair the wear and tear in the body.
(2) To regulate oxidation.
(3) To be used as heat-producers.
(4) To form fat.

2. **Fats.**—Fats are chiefly valuable as heat-producers ; their special functions are—

(1) The formation of fat in the body.
(2) The production of heat and energy.

3. **Starches and Sugars.**—Carbohydrates act in a very similar way to fats, and to a certain extent they are interchangeable with them. Their duties are, therefore—

(1) The formation of fat.
(2) The production of heat and energy.

It is generally taught that in cold climates the fats should be increased, and in warm climates the carbohydrates; but we dispute this statement, and consider that the amount of food of all varieties should be much the same in all latitudes.

4. **Salts.**—The salts necessary for the preservation of health are many. The salts of the vegetable acids, such as are found in fruits and vegetables, are essential for our tropical dietaries. When absent or deficient from food, a state of malnutrition results, which, if continued, develops into scurvy. Fruits and fresh vegetables, therefore, are very important articles of diet, though of small nutritive value.

Chief amongst the mineral elements of the body we find common salt, an imperative necessity for life and health.

It supplies the soda necessary for the salivary digestion, and the chlorine for the hydrochloric acid of the gastric juice.

Next to it, lime, phosphoric acid, potash, and soda, are the most important mineral solids. Sulphur is present in all proteins, and is an important ingredient in the dietary. Iron is found in small quantity in almost every tissue of the body, and it is an essential constituent of the blood.

5. **Water.**—Water, to the extent of $2\frac{1}{4}$ to 4 pints daily, is, as we have seen in the last chapter, an absolute necessity of life. Though not itself undergoing any chemical change, its presence is a necessary

condition for the occurrence of chemical change in other bodies.

Condiments play a very important part in the food of both European and native in the tropics, as they are substances which give flavour to the often tasteless articles of food, such as rice, which bulk largely in tropical dietaries. In addition, they stimulate secretion and digestion, but they do not, of course, form tissues or evolve energy.

The nutritive constituents of food, in accordance with their functions in the body, may be classified as follows :

Tissue-Formers.	*Work and Heat Producers.*
Proteins.	Proteins.
Mineral substances.	Carbohydrates.
Water.	Fats.

Dietaries.

Hutchison distinguishes four criteria of the value of a dietary : (1) Nutritive value ; (2) heat-producing power ; (3) digestibility ; (4) cheapness.

A good standard diet adapted to English habits, and suitable for a man doing a moderate amount of muscular work, is constituted as follows :

Foundation.—One pound of bread, 8 ounces of meat, 4 ounces of fat.

Accessories.—One pound of potatoes, ½ pint of milk, 4 ounces of eggs, 2 ounces of cheese.

These amounts divided up into the four ordinary meals would give the following dietary :

Breakfast.—Two slices of bread and butter and two eggs.

Dinner.—One large plateful of soup ; a large helping of meat, with some fat ; one slice of bread and butter.

Tea.—A glass of milk and two slices of bread and butter.

Supper.—Two slices of bread and butter and 2 ounces cheese.

The following are typical Indian dietaries :

(1) **For Bengalis doing Very Little Work**—*Early Morning Meal.*—Six ounces boiled rice, with a little dal and vegetables ; or 4 ounces atta (flour), in the form of unleavened bread, with $\frac{1}{3}$ drachm salt ; and a little ghee (clarified butter) and vegetables.

Meal at Midday.—Ten ounces rice ; 3 ounces dal, fish, or meat ; 4 ounces vegetables ; $\frac{1}{4}$ ounce ghee or oil ; $\frac{1}{4}$ ounce each salt and condiments.

Meal at Night.—Exactly same as the midday meal.

(2) **For Bengalis doing Hard Work**—*Early Morning Meal.*—As for (1).

Midday Meal.—Twelve ounces rice ; 4 ounces dal (lentils), fish, or meat ; 4 ounces vegetables ; $\frac{1}{4}$ ounce each ghee or oil, salt, and condiments.

Meal at Night.—Same as at midday meal.

(3) **For Natives of Northern India doing Light Work** — *Morning Meal.* — Four ounces wheat or maize flour ; 3 ounces rice ; $\frac{1}{4}$ ounce salt, with a little ghee and vegetables.

Midday Meal.—Three ounces wheat or maize flour ; 3 ounces rice ; 3 ounces dal (or, if a meat or fish eater, 4 ounces instead of dal) ; 4 ounces vegetables ; 1 ounce ghee or oil ; $\frac{1}{4}$ ounce salt and 1 ounce condiments.

Meal at Night.—Same as midday meal.

(4) **Native of Northern India doing Hard Work**—*Morning and Night Meals*—As for (3).

Midday Meal.—Six ounces wheat flour, or 7 ounces maize flour, and $\frac{1}{2}$ ounce ghee [instead of 1 ounce as at (3)]. The rest exactly the same (Bedford).

The diets of Indians and other tropical natives are, of course, often varied by the introduction of other kinds of food, such as eggs, milk, cheese, fowls, etc. The more the diet can be varied, the better ; for

variety in food gives a better appetite and renders digestion easier.

The following are the daily scales in general use in the Bengal gaols :

	In Lower Bengal. Ounces.	In Behar. Ounces.
Burma or country rice ..	20	16
Different dals	6	6
Vegetables	6	6
Flour of wheat or Indian corn	—	10 or 12

These represent the amounts absolutely essential, and a better standard may be taken in the war ration of the Indian sepoy, which consists of 2 pounds atta or rice, 2 ounces ghee (clarified butter), 4 ounces dal (lentils), $\frac{3}{4}$ ounce salt ; also meat and condiments on payment. In some later expeditions onions and amchur (dried mango) have been issued.

The following ration has been issued to Aden camel-drivers : $1\frac{1}{2}$ pounds biscuit or rice, 1 pound wet dates, 2 ounces ghee, 2 ounces sugar, $\frac{1}{3}$ ounce coffee, $\frac{1}{2}$ ounce salt, 2 ounces onions (when procurable), or $\frac{3}{4}$ ounce dal.

More than these amounts are usually consumed. Chittenden considers that the current estimations of the amount of proteid and total fuel value necessary for hard work are excessive ; but the recent researches of McCay at the Medical College, Calcutta, do not support his view.

The body seeks to maintain a reserve supply of nitrogenous food for its cells. A man having a small reserve supply may be considered to be on a low plane of nutrition, and one with a large reserve on a high plane of nutrition. Those on a high plane are better able to resist such infectious diseases as beri-beri, leprosy, tuberculosis, pneumonia, typhoid fever, typhus, relapsing fever, and plague, than those on a low plane. White men in the tropics,

when not liberally supplied with nitrogenous food, fall ready victims to infectious diseases. They have placed themselves, from a dietetic standpoint, on a level with the native, and, like them, soon succumb to an infection that their wiser or more fortunate brothers are able to successfully resist. Sir Patrick Manson says that many of the natives of the tropics are in a state of chronic starvation ; hence the folly of intentionally placing white men in the same condition is apparent. The immunity of Englishmen to the infectious diseases that decimate the natives of tropical countries is due—in part, at least—to their being better fed on nitrogenous food.*

Animal food possesses certain advantages over vegetable, of which the most certain are the ready supply of blood-pigment, the larger percentage of proteins, the greater digestibility of animal fats, and the smaller bulk required. A vegetable dietary, unless carefully selected, usually contains insufficient nitrogen and an excess of carbohydrates. It is bulky, less digestible in the stomach, and less completely absorbed. Vegetable albuminoids are less rapidly digested than those derived from animal sources, but a well-fed vegetable-eater may display for a time as perfect health and energy as a meat-eater. On the other hand, the argument from analogy with the herbivora, some of which are types of activity, is valueless, as man cannot digest cellulose or vegetable fibre, whereas the horse or other animals can. The consistent vegetarian must either live on a diet deficient in protein or consume an excessive bulk of food. The adoption of the former course tends to diminish energy and tissue resistance, and the latter is likely to lead to derangement of the digestive organs (Whitelegge and Newman).

* The natives of India are firm believers in a liberal dietary. One of their favourite proverbs is, *Khya seer buna sher*, meaning he who eats a seer (2 pounds) of flour becomes a lion in strength.

Nitrogenous Foods.

The various kinds of flesh present no special points for consideration in the tropics, except the deficiency in flavour already referred to.

They are popularly held not to possess the same nutritive qualities as in temperate climates, but this contention is not easy to establish experimentally.

The inferior quality of tropical foodstuffs is generally due to carelessness in production.

For instance, the smallness of the Indian egg is due to the want of care in breeding fowls and in feeding them. They are generally allowed to pick up any food they can get. There is no reason why large fowls and large eggs should not be obtainable in hot climates; and where residents have the energy to go in systematically for poultry-farming, it always pays.

Milk.—Milk, being designed for the nutrition of the rapidly-growing young animal, contains a very large proportion of water, and a relatively large proportion of fat and protein in comparison with the carbohydrate constituent. It is not, therefore, a food suitable for the entire nutrition of the adult; but for the infant it is essential, whilst for the invalid and the elderly it is most valuable. One pint of average good milk contains about 2½ ounces of water-free food; 1 pound of meat contains about 4 ounces; but not all of this is perfectly digestible, as is the case with the whole of the solids of milk.

As a rule, in the tropics milk should be boiled or pasteurized before use, as many diseases, such as tuberculosis and enteric fever, are spread by contaminated milk. Boiled milk is said to be more digestible than fresh milk; it is, however, less palatable to most people, and no doubt loses some of its nutritive value and some important salts in boiling;

but whatever disadvantages boiled milk may have, they are outweighed by the security thereby afforded against so frequent a source of infection by specific disease poisons.

Cream is a most valuable and nutritious food, easy of digestion in moderate quantity.

Skim milk and whey are not very nourishing, but are easy of assimilation, and are agreeable articles of food, for invalids.

Cheese.—Cheese does not receive the amount of consideration it deserves in tropical dietaries. It is much better as a food than meat.

That cheese is not readily digested by delicate persons is well known ; but this indigestibility is very often a fault of the consumer rather than of the cheese. Properly eaten by a person of fair digestion, it is one of the most digestible of foods. The fat, which forms one-third of its composition, forms a waterproof coating, which prevents the access of the digestive juices to the casein. The larger the lumps of cheese which reach the stomach, the slower will the access be. Hence the importance of reducing it to a state of fine division before it is swallowed. This may be done by carefully chewing with some farinaceous substance, such as bread or biscuit.

The process of mastication may be assisted by grating the cheese ; but the best plan for those who find any difficulty in digesting raw cheese is to dissolve it and mix it with some other food—preferably a carbohydrate, which is the natural complement of a proteid and fatty food.

The best solvent of cheese is bicarbonate of potash, because casein forms soluble compounds with the alkalies. About 5 grains of bicarbonate of potassium is sufficient to dissolve 4 ounces of cheese, either grated or chopped into small fragments. By the

addition of milk and eggs a very savoury and exceedingly nutritious pudding can be prepared, which is a grateful change in tropical dietaries.

The proper place for cheese in a well-arranged diet is as a substitute for, and not as an appendage to, meat. There is, however, one exception to this rule, and that is the correctness of taking a small piece of cheese at the end of a meat meal, for, paradoxical as it may seem, digestive reasons.

According to the old adage, cheese is a "crusty elf, digesting all things but itself"; and in this there is the element of truth. Cheese contains elements of the character of ferments, which tend to set up a fermentation process in the food when it passes into the stomach, and thus to promote digestion. But if cheese be taken in excess at such a time, the digestive action is paralyzed, and indigestion is the natural consequence, thus justifying the wisdom of our forefathers.

The cheaper cheeses are often more nourishing and more digestible than the expensive ones.

Butter.—Good butter should be of a rich yellow colour, which deepens with the richness of the pasture. Cows kept in the house on hay and dry food give an inferior product, whilst buffalo cream always yields a dead white butter. Various substances, such as annatto and an Indian nut called *lutka*, are added to increase or produce the popular colour. Butter from moderately ripe cream has a fine flavour, and when well made ought to remain good and sweet for a week. Butter prepared from pasteurized cream is lacking in flavour.

Ghee, or clarified butter, takes the place of butter in the diet of most Indians. It is a wholesome and nutritious fat, but the peculiar flavour does not appeal to Europeans.

The Vegetable Foods.

These may be divided into five groups :

Group I. : Cereals.—These comprise the edible grains, such as wheat, oats, Indian corn, rice, etc. Of these, wheat is preferred as a food, for the following reasons :

(1) The grain is easily separated from the chaff, which does not adhere to it, as in the case of barley, oats, rice, etc.

(2) The yield of flour is very large.

(3) Owing to the peculiar constitution of wheat, light and spongy bread is readily made from it.

(4) The proportion of the chemical constituents present renders it well fitted for the general sustenance of man (Church).

Bread.—Bread can be manufactured in a variety of ways, but all methods aim at the aeration of a mixture of flour and water, and subsequent cooking at a temperature of about 450° F.

A good sample of bread should be well baked (not burnt), light and spongy, the crumb being well permeated with little cavities. It should be thoroughly kneaded, of good colour (brown or white), not acid to the taste, not bitter, not too moist. When set aside, the lower part should not become sodden. A four-pound loaf loses about $1\frac{1}{4}$ ounces in twenty-four hours, about 5 ounces in forty-eight hours, and about 7 ounces in sixty hours. This loss will vary with the temperature, draughts of air, etc.

Bread may have the following defects :

(1) It may be *sodden* or *heavy*, owing to bad flour or yeast, the sponge never having risen properly, or owing to imperfect baking.

(2) It may be *sour*, owing to bad flour, or to fermentation having been allowed to proceed too far. A slight degree of sourness in leavened bread is not objected to.

(3) It may be *bitter*, owing to bitter yeast.

(4) Finally, it may be *mouldy*, which is due to the bread having been too moist originally, having been stored in a damp place or kept too long, or to bad flour having been used.

Biscuit.—Biscuit should be well baked, but not burnt. It should float and partially dissolve in water. When struck, it should give a ringing sound, and a piece put in the mouth should thoroughly soften down. Being almost free from water, biscuit contains a large amount of nutritive material in an easily digestible form, and keeps for a considerable time. Three pounds of biscuits are equal in nourishment to 5 pounds of bread.

Oatmeal.—Oatmeal is the most nutritious of all cereals. It is very rich in fat. Oats prepared by rolling instead of grinding, and heated during the rolling process, are much more digestible and easily cooked than ordinary oatmeal. Prepared in this way, the cereal constitutes the much-advertised preparations of oats, under various fancy names, which are now so deservedly popular.

Maize. — Maize, or Indian corn, is extremely nutritious, but it has some disadvantages. Owing to the large amount of fat, it develops a disagreeable rancid flavour on keeping, and, from its deficiency in gluten, it is not adapted for making bread, unless mixed with wheat flour.

It is, however, all things considered, one of the best of our tropical foods.

Cornflour is prepared from maize by washing away the protein and fat by means of dilute alkaline solution, so that little but starch is left.

Rice.—Rice is the poorest of all cereals in proteid, fat, and mineral matter. On the other hand, it has fully 76 per cent. of starch. The starch has the further advantage of being present in small and

easily-digested grains. When boiled, rice swells up, and absorbs nearly five times its weight of water, while some of its mineral constituents are lost by solution. It is preferable, therefore, to cook it by steaming.

Rice is only moderately easy of digestion in the stomach, $2\frac{1}{2}$ ounces cooked by boiling requiring three and a half hours for disposal.

On the other hand, rice is absorbed with very great completeness in the intestine ; indeed, its solid constituents enter the blood almost as completely as those of meat. This is to be attributed to the comparative absence of cellulose. Practically none of the starch is lost, but the waste of proteid amounts to about 19 per cent. It follows from this that rice is one of the foods which leaves the smallest residue in the intestine, and this gives it a considerable value in some cases of disease.

The nutritive value of rice is much impaired by its poverty in proteid and fat. Hence it is not adapted to be an exclusive diet, but should be eaten along with other substances rich in these two elements, such as eggs, cheese, or milk. Even as regards carbohydrate, it would require about 1 pound 3 ounces of rice to furnish the daily need of an active man. This would entail the consumption of about 5 pounds of cooked rice daily (Hutchison).

Group II. : The Pulses—Lentils, such as the various kinds of "dal," are similar in composition to, but richer in phosphates than, peas and beans, and contain less sulphur.

The group is rich in protein—chiefly legumen, a substance allied to the casein of cheese. They are also rich in carbohydrates. Salts are fairly abundant, but phosphates are less so than in cereals. Like wheat, the seeds are weak in fat, and therefore require mixture with fats and carbohydrates to form

a complete diet. Gram and ghee with potatoes is an example of a complete diet.

A mistake is very often made, chiefly by Europeans, in taking leguminous seeds as a vegetable with meat. Dal should therefore be used as a substitute for meat, and it is best combined with rice, which we have already seen to be deficient in proteids.

Group III.: The Roots and Tubers.—These consist chiefly of carbohydrates, mostly in the form of starch, and very little other food material.

Potatoes.—This tuber consists of starch, sugar, and a trace of protein. When well cooked it is easily digestible. The salts found in the juice of a potato are a complete preventative of scurvy.

Beetroot.—Beetroot when young is of some value as a food, on account of the sugar it contains.

Carrots and *Parsnips* are of rather less value than beetroot.

Turnips are of little value as a food, and are liable to cause flatulence and dyspepsia.

Group IV.: Green Vegetables and Fruits—*Green Vegetables.*—These consist of large quantities of water, much cellulose, and small quantities of sugar, gums, and allied bodies. The members of this group are chiefly valuable as flavouring agents, antiscorbutics, and natural stimulants to the action of the bowels. They have little or no nutritive value.

Onions.—These vegetables are valuable as condiments. They contain a larger amount of phosphates than any other succulent vegetable, excepting asparagus, and have a slight laxative action on the bowels. They are also said to be very valuable for persons with a rheumatic tendency.

The *Succulent Fruits* have a low nutritive value, but are rich in vegetable salts ; they are antiscorbutics of incalculable value.

Vegetables used in Salads are valuable antiscorbutics.

The salts are not lost by wasteful cookery. The uncooked cellulose greatly stimulates intestinal action, but it is apt to upset the digestion. Cholera, enteric, and other diseases, may readily be conveyed by uncooked vegetables. For this reason, only vegetables grown under personal supervision and carefully washed before use should be eaten. Both on account of their indigestibility, therefore, and the danger of contracting cholera or enteric fever, we are strongly of opinion that in tropical countries salads, as a rule, should be avoided.

Watercress is often grown in sewage water, and may spread enteric fever and worms. Even when obtained from the best sources, it should be well soaked in strong salt water, and then well washed in boiled water, before use.

Group V.: Albuminous Nuts.—The edible nuts, such as the walnut, are generally very rich in proteid matter and fats. They also contain some carbohydrates. The difficulties in their digestion are often great. These difficulties are diminished by grinding the nuts into a fine powder.

Beverages.

The beverages of civilized man the world over are—

1. Alcoholic liquors.
2. Tea and coffee.
3. Aerated waters.

1. **Alcohol.**—In *childhood* alcohol as a beverage is most injurious; in *adult life* a strictly moderate amount, with ordinary diet, may be taken or not, but it is not a necessity; *in old age with failing strength and weight* alcohol is most useful; *in old age with increasing weight and obesity* alcohol is most injurious: it increases the tendency to fatty heart,

kidney troubles, and to apoplexy, with paralysis or sudden death.

Moderation for adults may be defined as 1 ounce of alcohol daily, which may be consumed in any of the following forms :

1 pint of fairly strong dinner ale.
1½ pints of light table or lager beer.
½ pint of light claret.
2 wineglasses of port or sherry.
3 or 4 tablespoonfuls of brandy, gin, or whisky.

Cantlie says : " The natives of warm climates, both by their religion and their habits, shun alcohol. It is in no sense a food, and Europeans in tropical countries would do well to avoid its use altogether. Spirits and beer in hot, moist climates are positively detrimental to health ; light wines, white or red, do least harm ; champagne taken after excessive fatigue, about sunset, is perhaps the safest form of alcoholic beverage. It should not be taken with meals, but only on reaching home after a fatiguing march or long exposure to wet."

Dr. Cantlie's statement is hardly correct, as the Hindus all over India, from the Sikh of the Punjab to the Madrassi butler of Trichinopoly, will drink all the alcohol they can get hold of.

2. **Tea, Coffee, and Cocoa**—(1) *Tea.*—As a stomachic tonic and as a safe way of introducing fluid into the system, tea is beneficent and hygienic. It was evidently introduced by the Chinese, owing to the calamities arising from drinking unboiled water. Deep-well water is almost unknown in China, and the shallow wells and streams are so apt to become polluted, owing to the habits of the Chinese, that experience dictated the necessity of boiling water. But boiled water being insipid, and the object of its being boiled not being evident to an ignorant and

thoughtless people, the water was flavoured by the leaves of the tea-plant—a custom which has become widespread. It was, no doubt, for hygienic purposes that tea was introduced, but the abuse of tea-drinking has brought many evils in its train. The Chinese drink tea after their principal meal, and, in fact, as a drink at any time. They do not drink tea during their meal, but after the meal is finished. The pernicious system of drinking tea during a meal is one peculiar to British folk, and the habit is the cause of many dyspeptic troubles. The best China tea, prepared by pouring boiling water over the leaves and immediately pouring off the water, is a wholesome fluid, calculated to aid digestion, especially when taken after the meal is finished. Tea taken with animal food, be it eggs, fish, flesh, or fowl, is a certain means of producing dyspepsia; for when the tea is "drawn" for a long time, and when the tea used is of an inferior quality—the method and material usual in Britain and Australia—the tannic acid of the decoction, uniting with the albumin of the animal tissues, produces a leathery compound, which no gastric juice, however potent, can penetrate and digest. Tea used in the Chinese fashion is a hygienic drink; as ordinarily consumed in Britain and by Britishers throughout the Empire it is detrimental to the public health. The "afternoon tea" is an unnecessary and useless meal, especially when tea-drinking is merely an excuse for the eating of large amounts of hot buttered buns, scones, rich cakes, and such-like indigestible articles.

(2) *Coffee*.—Two or three mouthfuls of good coffee after a meal are an aid to digestion; taken in breakfastcupfuls it is an impediment to digestion, and diluted with half milk, and taken with a meal of eggs, fish, fowl, or flesh, is still more so. Taken at night, it frequently causes insomnia.

(3) *Cocoa.*—Cocoa contains a similar alkaloid to tea and coffee. It is, however, present in smaller quantity. In the way cocoa is generally taken the whole of the seed is eaten, so that, in addition to a stimulant, some food matter, principally of a carbohydrate kind, is taken. It is, however, inconsiderable in amount, as the total weight of cocoa eaten is so small.

Condemnation cannot be too strong in regard to the habitual use of the drugs *coca* and *kola* in medicated wines. The action of the stimulating alkaloids which they contain is insidious, and a craving is often set up, leading to cocainomania.

3. **Aerated Waters.**—These consist of water, or solutions of salts, with or without sugar and flavouring agents, aerated with carbonic acid gas. Carbonic acid gives a brightness and pleasant flavour to the water. Provided that no metallic poisons are added from lead, etc., in the machine used in preparing the water, simple aerated waters are not injurious; but it should be understood that, while carbonic acid gas under pressure has some germicidal properties, it does not render a polluted water safe for drinking.*

Cooking.

The objects of cooking are twofold:

1. **Æsthetic,** to improve its appearance and to develop in it new flavours.

2. **Hygienic,** to sterilize it to some extent, and to enable it to keep.

It is an error to suppose that cooking increases the digestibility of food. This is only true with regard to vegetable food. The digestibility of meat is

* The germicidal action of carbonic acid is most marked with reference to the cholera vibrio. It acts slowly, so that aerated waters should be kept for at least a week or ten days in order to obtain it.

diminished by cooking, although the increased attractiveness of cooked meat may render it indirectly more capable of digestion, by calling forth a more profuse flow of the digestive juices.

Ordinary cooking or pickling affords little protection if meat is infected with the germs of disease.

Diseases caused by Food.

Overfeeding.—An excess of food, due to too large or frequent meals, may accumulate in the intestine, causing fermentation and dyspepsia, with constipation or ineffective diarrhœa. Gout, obesity, gall-stones, and other conditions, may arise from excess of food. Absorption of the products of putrefaction may give rise to a septic condition, marked with fever, furred tongue, fœtid breath, heaviness, and possibly jaundice. Diseases of the blood may also arise from retention of waste products in the intestine.

Underfeeding.—Protracted insufficiency of diet is followed by wasting of the tissues. Adipose tissue is naturally the first to suffer, and may be almost completely absorbed, the other tissues following mainly in the inverse order of their importance to life. Physical and mental weakness ensue, followed by a debilitated condition that powerfully predisposes to certain diseases, notably relapsing fever, phthisis, and pneumonia, and perhaps all infectious diseases. Diarrhœa is apt to occur, adding still further to the general emaciation and prostration. Ophthalmia, ulcers, and skin diseases of various kinds, are common, and any disease that may have obtained a hold upon the system is aggravated by the impairment of nutrition. Death ensues when the loss reaches about 40 per cent. of the normal weight of the body.

In conclusion, health may become affected by articles of food in the following ways :

1. The essential constituents of diet may be deficient or in excess.

2. Poisonous substances may be derived from the vessels in which the food has been stored, as in the case of tinned provisions.

3. Injurious substances may be added by way of adulteration, by improper manufacture, or by the drugging of animals before death.

4. Certain kinds of shellfish are liable to be occasionally poisonous, even in the fresh state, and disease may be conveyed by oysters, watercress, etc., grown under unhygienic conditions.

5. Putrefactive changes may have commenced in the food, and produce grave intestinal disturbance.

6. Poisonous substances, such as tyrotoxicon, may be developed, either as a result of fermentation or from unknown causes.

7. The flesh or milk of an animal suffering from certain specific or parasitic diseases, such as tuberculosis, trichinosis, hydatids, may impart the disease.

8. Vegetables may convey actinomycosis.

9. Food, especially milk, may become infected by the virus of diphtheria, enteric fever, cholera, or scarlet fever, from close contact with persons suffering from these diseases.

Disease in the individual, or more rarely idiosyncrasy, apart from disease, may render certain kinds of food, such as shellfish, injurious, which to ordinary persons are wholesome. Finally, there are certain food accessories, such as alcohol and tea, which may be injurious if used injudiciously.

CHAPTER V

CLOTHING IN THE TROPICS

In hot climates the surface of the body is best protected by a material which will readily reflect the sun's rays. But clothing has to be regulated according to its power of absorbing moisture, and to its non-interference with the healthy action of the skin and the free movements of all parts of the body. Moreover, its subsidiary uses, such as the protection of certain parts from pressure, as in the wearing of boots and shoes, and its adaptability to keep out wet, are points which require consideration.

The materials worn in the tropics are wool, silk, cotton, linen, and leather.

Wool.—Wool forms the natural covering of animals in cold and temperate climates. It owes its value to the fact that it contains an oil or fat, and that the wool, when woven into cloth, has numerous interstices, which imprison air and prevent heat passing through it; hence flannel is not only warm, but cool. It should always be worn during the cold and rainy season in the tropics, and in "hill stations." During the hot season its desirability is doubtful.

The natural oil of the wool is one of the most important constituents of flannel, but, unfortunately, bad washing frequently removes this natural grease, and leaves the material practically worthless. Woollen goods should therefore be washed in water which is only just warm, and soap, which should be of a good

quality, used sparingly. A little kerosene-oil added to the water will remove gross dirt.

It is not necessary that underclothing should be of pure wool. For hot climates it is difficult to obtain it either thin or soft enough for comfort, but various mixtures of wool and cotton, and loosely-woven cotton materials, possessing all the advantages for tropical wear of pure wool, are on the market.

In the choice of woollen underclothing, the touch is a great guide. There should be smoothness and great softness of texture; to the eye the texture should be close, the hairs standing out from the surface of equal length, and not long and straggling. The heavier the substance is in a given bulk, the better. In the case of blankets, the closeness of the pile and the weight of the blanket are the best guides.

In woollen cloths the rules are the same. When held against the light, the cloth should be of uniform texture, without holes; when folded and suddenly stretched, it should give a clear ringing note. It should be very resistant when forcibly stretched, as the "tearing power" is the best way of judging if "shoddy" has been mixed with fresh wool.

Silk.—Silk, next to wool, is the best material for tropical underwear. The soft and soothing feeling of a silken vest is due to the fact that silk fibres are beautifully smooth, whereas wool, which is merely a variety of hair, presents a rough surface.

Cotton.—Cotton has the great practical advantage of being hard, durable, and cheap. It is introduced into most woollen materials to increase their durability and to prevent shrinking; for instance, it constitutes nearly a quarter of the excellent flannel from which the familiar grey shirt of the soldier is made.

In the form of various types of cellular clothing it is a capital material for hot-weather wear.

Specially woven and dressed, it is very largely used as "flannelette." This material, on account of its inflammability, is dangerous for wearing apparel.

Linen.—Linen possesses no advantages over cotton as an article of clothing. It can be woven into finer materials, and takes a high finish, so that it must be judged from an æsthetic rather than a hygienic point of view.

India-Rubber, Oilskin, and Waterproof.—Special waterproof fabrics have a very wide use during the rainy season. The following is a useful recipe for waterproofing ordinary materials.

Take 5 ounces of lanoline or wool fat, and dissolve it in a gallon of petrol. The clothing is then immersed in the solution, the garment wrung out, and the excess of solvent allowed to evaporate rapidly in the air.

Clothing impregnated with wool fat in this way may be worn both in rain or sun without ill effects. It permits the rapid evaporation of perspiration, and affords a better protection against rain than do fabrics waterproofed with alum preparations or other chemicals. Such garments are even more permeable to air than ordinary clothing, and also absorb less watery vapour. Moderate washing has no effect on the waterproofing, so that the effects of the procedure are fairly permanent. The expense is inconsiderable, the cost of waterproofing a suit of clothes being less than half a crown.

Boots.—Boots should be carefully fitted at all times, but require special consideration in the tropics.

They should be invariably "tried on" over a thick pair of socks, and may well be a size bigger than is actually necessary, to allow for the swelling of the extremities which is associated with hot weather,

and for expansion of the foot in active exercise. They must not be tight over the instep, and great pains should be taken to see that there is plenty of room for the toes, especially the little one. The soles should be pliable, nothing being so tiring as a tropical walk in shoes with stiff soles. New boots should be frequently used for short distances before being worn for any length of time.

Castor-oil is one of the best materials to rub into boots used for sporting purposes, to render them soft and pliant. In Europe it is not very largely used for this purpose, on the score of expense, but in the tropics it can often be obtained extremely cheaply.

Boots should always be worn in preference to shoes, in order to protect the ankles from the bites of mosquitoes.

Leggings and Puttees.—Experience has shown that a well-fitting legging is the best covering for riding, whilst the puttee forms an excellent protection for the lower extremities for walking. Like boots and socks, these articles require careful attention, as a tight-fitting legging or a carelessly-applied puttee spells misery to the individual wearing it.

Drawers.—Everyone should wear drawers in the tropics. They promote cleanliness and protect the internal organs from chills.

Cholera Belt.—The flannel belt much extolled by the older writers generally fails to answer the purpose for which it is intended. It is very difficult to keep in position, and either rucks up under the ribs or lies in a roll above the hips. In either case it is of little value as a protection, and after exercise it becomes converted into a wet poultice over the abdomen.

The use of the cholera belt should be restricted to night wear, when it is most useful. If a blanket is relied on in hot weather, it is frequently tossed off by the restless sleeper, with the result that the ab-

domen is chilled by the draught of the punkah or fan.

In the tropics this is undoubtedly a source of danger, and it should be carefully explained to recent arrivals in hot countries that, whereas chill in temperate climates usually leads to nothing more serious than coryza, in hot countries it is very likely to be followed by intestinal troubles.

The colour of articles should be carefully considered when deciding the question of general suitability. It is well known that different colours possess, in varying degrees, the power of absorbing heat. Black has the highest capacity for absorption, white has the least, the order in which different colours absorb heat being as follows: Black, dark blue, light blue, dark green, turkey red, light green, dark yellow, pale straw, and white.

An experiment was recently made in the Philippines amongst the military forces of the United States Army, with reference to the value of orange-red underclothing as a protection against heat, and especially as a preventive of heat exhaustion. This experiment was made following the report of the British officers in India, that such clothing was much more comfortable than khaki or white in hot weather. The test clothing was distributed to half the men in each company, the other half wearing white garments of like texture as a control. In all 500 men wore the orange-red underwear, under similar conditions of physique, food, and service, and careful records were kept of comparative amounts and nature of sickness amongst them, their feelings as to comfort or discomfort in the sun, their mental and bodily vigour, etc. The experiments continued for a year, and a record of the weights and blood-examinations were kept throughout this period. It was found that the record of sick admissions was about the same for

both groups; they suffered equally from the heat of the sun, but those of the orange-red group suffered more from excessive perspiration, there was a greater loss of weight in the hot season by nearly a pound per man, and the blood-changes noted in tropical climates—decrease of red cells and loss of hæmoglobin—were more pronounced. The blood-pressure also showed a greater loss, and the temperature, pulse, and respiration, showed a slightly higher rate for this group. The admissions for heat exhaustion and febricula were not reduced by the orange-red clothing, and the symptoms due to heat were about the same in the two groups. Only 16 men out of 500 preferred the coloured underclothing, and the persistent complaints of greater heat, greater weight, and excessive perspiration, indicated that the coloured garments were more receptive to the heat rays than the white. The conclusion of the board conducting the experiment was that the orange-red clothing added materially to the burden of heat on the system, and that no beneficial effects were observed from its use.

The Clothing of Children.—An infant requires to be especially protected by clothing, because it loses heat quickly by evaporation, its surface being large in proportion to its bulk.

Babies should wear wool next to the skin all the year round in the tropics, only varying the thickness to suit the season. It shows a poverty of resource to expose the upper and lower parts of the bodies of children in order to give them greater freedom of movement. This can be accomplished without depriving them of clothing. Deprivation of clothing has distinctly injurious effects upon children, who require a large amount of heat to enable them to carry on the process of growth and development. The habit, therefore, of tying up a baby's sleeves

with ribbons, and allowing older children to run about with the legs bare, cannot be too strongly condemned, as a large part of the body is thereby exposed to sudden chilling. A child has only a certain amount of nerve force available for the vital functions of breathing, digestion, etc.; and if an undue amount of this is expended in the maintenance of bodily heat, the other functions suffer, with the result that digestion is enfeebled and constipation or diarrhœa ensues.

Even in the tropics, therefore, a child's clothing should be soft, light, warm, and loose, and so arranged that it can easily be taken off. Every garment should be made to fasten with tapes and buttons, and an infant's binder should invariably be sewn on, and not fastened with a safety-pin.

Long clothes are universally condemned by all authorities.

A l children should wear a vest of natural wool in the cool season, and silk in hot weather. Older children should wear combinations, as these garments avoid undue pressure round the waist.

Children's bedclothes should be light and warm, and the coloured insanitary blankets, which are so popular in the tropics, should be replaced by white blankets, which *do* "show the dirt."

Mackintoshes should be placed over the children's mattresses, but they must *never* be put on over a baby's napkin, as the rubber causes irritation of the skin. Eiderdown quilts are undesirable for children's beds, as they are not porous and cannot be washed.

Children's boots should be made by a good bootmaker, and the only point to be insisted on is that the inner edge of the sole should be in a perfectly straight line, and not inclined towards the outside from the ball of the toe forwards.

Children's boots should invariably be made to lace

up, and not to button. This method of fastening allows of making one part tight and another loose, as circumstances require. They should only be laced as far as the last hole but one, and tied *loosely*. If laced right up to the top, the bootlace often slips on the leg, and chafes and constricts it.

Sandals have been strongly advocated for children, but they are not recommended for use in the tropics, as they do not protect the feet from the bites of mosquitoes.

Babies' heads should not be wrapped up, especially in the tropics. For older children light, loose-fitting topees and hats should be used, and headgear of the type of Dutch bonnets avoided. A light, broad-brimmed, mushroom-shaped sun-hat is all that is necessary for wearing in the sun, whilst a similar covering in light straw is easily devised for use after sundown. The sun-hat must be worn out of doors even in the early morning, as the sun is just as likely to produce sunstroke in the morning or evening as in the middle of the day.

Corsets should not be worn by children, and girls should wear an easy-fitting blouse, knickers, and shirt suspended, like a boy's trousers, by straps over the shoulders; but "braces" strictly so called, "for improving the figure," should not be used.

Laundry Work in the Tropics.

Supervision of laundry work is a point with reference to clothing which receives too little attention in the tropics. In the East it is no uncommon thing to see clothes being violently beaten on stones, a process destructive to all fabrics, and notably so in the case of flannel.

In addition to the absence of all ordinary skill and care, the washing is carried out in any dirty stream or pool that may happen to be convenient, and in

many places the washing is carried out in streams which, owing to their receiving the drainage of the city, are much polluted, and in this way handkerchiefs and other articles of intimate use become contaminated with bacteria.

The ironing and storage of the *clean* (?) clothes is usually as badly carried out as the washing itself. Too often the clothing is ironed in the bazaar, and stored a night or two in the washerman's living-room, before it reaches the owner's bungalow. This may account for some mysterious outbreaks of disease amongst the European communities in tropical towns.

CHAPTER VI

SITES, SOILS, AND HOUSES

THE requirements for a healthy tropical dwelling are seven in number—namely :

1. A soil suitable for building purposes.

2. A site which is dry and an aspect which gives light and cheerfulness.

3. A system of sewage removal sufficiently adapted to modern life to insure speedy removal of noxious material from the environment of the residents.

4. Proper means of ventilation.

5. A proper system of construction which will insure perfect dryness of the foundation, walls, and roof.

6. Proper means of cooling the rooms in hot weather.

7. Efficient means of lighting.

How far tropical conditions depart from these requirements is obvious from the fact that in olden times it was the fashion in many parts of the East for each new King to build a new city. The custom no doubt originated from the fact that after a certain number of years a town became so unhealthy that it was advisable to leave it.

The insanitary conditions which still prevail in tropical cities are appalling. For example, Bombay, the commercial capital of Western India, with an area of 14,300 acres and a population of fully 1,000,000, is one of the most densely crowded cities in the world. All available building areas in the

city have long since been taken up for building purposes, and the vast majority of its residents live in tenements.

There are but very few open-air spaces in the shape of parks, gardens, or other places of public resort, to act as "lungs" to the city. The extent of the overcrowding can only be realized by a nocturnal visit to one of the many Goanese residential clubs, or to one of the large tenement *chawls* in some of the most crowded parts of the city. In these sometimes as many as fifteen to thirty persons sleep in each room at night, while in some of the big four and five storied buildings from 300 to 500 people have been counted at the recent census.

Most of these tenements consist of very small rooms, ill-ventilated, damp, and unwholesome. They are crowded with people, many of whom go out to work during the greater part of the day, and are satisfied with the barest sleeping accommodation at night. Their drains are faulty, and the adjoining "open (?) space"—if there is one at all—consists of a dark and narrow gully, reeking with all kinds of noxious odours and poisonous emanations from leaky privies. To a very large number of such residential quarters in the city, these sweepers' passages constitute the chief, if not the only, ventilating space for the adjoining living-rooms. Generally speaking, the gullies are badly paved and badly drained, and some of them are in the most filthy condition imaginable. A European can scarcely conceive such a state of things in the heart of a town like Bombay.

1. Soil.

The health of a locality is intimately connected with the nature of the soil on which its houses are built.

Absorption of heat, under otherwise similar conditions, is determined by the nature of soil and vegetation.

Sand is most absorbent of heat; clay comes next; then chalk; and finally humus, or mould.

Trees and shrubs intercept the sun's rays, and, on the other hand, check evaporation from the surface of the soil, the net result being to render the ground cool and moist in winter, and cool and dry in the summer, when the leaves are out. The evaporation from leaves is very great, and tends to moisten and cool the air and abstract water from the soil.

Grass renders a soil cooler and more equable in temperature.

At a certain point below the surface is the subsoil water. Its level varies greatly. When the ground water rises, it forces air out of the soil, and at the same time may pollute wells by bringing into them the washings of impure soil. As the ground water falls again, it leaves the soil moist and aerated—conditions favourable for fermentation and putrefactive processes in organically polluted soil.

Recent experiments have tended to discredit previous reports that the enteric organisms can survive in soil for long periods.

Dampness of soil is favourable to phthisis and diphtheria, and, according to some authorities, to rickets also. Goitre is, however, credited with a more indirect relation to the soil.

Gravel soils are best for building purposes. Sandy soils are undesirable, unless covered with short grass. As turf is rarely seen in the tropics without irrigation and superabundant vegetation, the bare sandy soils which are common are very hot. Clay soils should be avoided, as they foster dampness.

2. Site.

It is essential always to build on the highest ground available, and invariably provide surface drainage, so as to prevent pools forming, which may become mosquito nurseries. The best site is a gentle slope on gravel soil.

Marshy and swampy ground should on no account be used for building purposes, and what are called "made soils" must be especially avoided. Such sites consist of hollows filled up with rubbish of all kinds, and are obviously full of impurities which must, and do, produce emanations prejudicial to health.

3. Sewage and Refuse Disposal.

Sewage and refuse disposal are fully dealt with in the next chapter.

4. Ventilation.

Ventilation has already been dealt with in Chapter III., but the sanitary officer must insist on an opening opposite all doors and windows, as it is absolutely essential to secure cross-ventilation in hot countries. Too often houses in the tropics have all their doors and windows at one side, and cooking and sleeping and eating are all carried on in one room. Cooking is done in the living-room with green wood, and the result is dense volumes of smoke, which find their way out as best they can. This smoke is very irritating to the eyes, and induces many of the eye diseases so common in the tropics. In the houses of the comparatively well-to-do, punkahs are often relied on to act as ventilators. They are practically useless for this purpose, as they merely agitate the air of the room, and do not draw pure air from outside.

5. Construction.

The following are the requirements of a tropical house :

Aspect.—It should front the north,* so as to have the principal rooms as cool as possible.

Plan.—The bedrooms should also face north,* or, if that is not possible, south, whilst all rooms intended for storage of food must have their windows to the north.

Foundations.—These should be sufficiently solid and deep-rooted to afford stability. If firm foundations cannot be obtained on the site, it is necessary to make artificial ones out of large blocks of concrete, on which the walls may rest. Each of these should be at least four times the breadth of the wall it supports, and at least 18 inches in depth.

Materials.—The shell of a house may be constructed of concrete, mortar, stone, bricks, wood, plaster, iron, or canvas.

Concrete consists of cement interspersed with broken brick, stone, and gravel. Portland cement is made from lime and dark blue mud clay from the lias formations.

Mortar.—Properly-made mortar consists of lime with clean sharp sand, but, unfortunately, mud mixed with chopped straw takes its place to an alarming extent in the tropics; indeed, it is difficult to know what the native architect would do without this useful but sordid material.

Stone.—The rocks most commonly used in building are the sandstones and limestones, both of which are easily worked and plentiful in some parts of the tropics.

Bricks.—In India and other tropical countries

* The text refers to the northern hemisphere. The direction must be reversed south of the equator.

bricks are of two kinds—*kutcha* and *pukka*. The former is made from mud dried in the sun, whilst the latter are made from "brick earth," which may consist of pure clay, clay loam, and clay marl. A brick should be well shaped, and all its angles should be right angles. The edges or solid angles should be sharp and clean. It ought to weigh 5 pounds, be twice as long as it is broad, and be homogeneous in character and colour, both externally and on section. The common dimensions are 9 inches by $4\frac{1}{2}$ inches by 3 inches. A brick can absorb as much as 1 pound of water, but if it absorbs more builders regard it as "overthirsty."

Wood.—For structural purposes, deal, pine, teak, and in India the wood of the shisham, or *Dalbergia Sissoo*, are chiefly used. The quality of timber depends on its rate of growth and its original position in the stem of the tree. The slower the growth and the nearer the centre of the tree, the better the specimen. A rough comparative test is the musical note given out by the wood when it is struck by a hammer. A good dense wood gives a clear, ringing note.

No timber can withstand alternate wetting and drying, or heat and moisture, without adequate ventilation. Under such conditions decay sets in, especially if lime be adjacent; hence the ends of house beams are liable to early degeneration. Two peculiar diseases affect timber—namely, dry and wet rot—the exciting causes being fungi. Wood suffering from either form of rot must be removed, as it favours the development of wood-lice, and therefore sand-flies. Protection from decay is best secured by forcing creasote under pressure into the wood, or, in the case of external woodwork, by painting and varnishing.

Plaster.—The best quality consists of lime or cement bound up with sand and hair; but the lime

plaster generally used in the tropics consists of bricks ground up with lime.

Walls.—The walls, for purpose of stability, must rest on a broad base. These broad bases are called the "footings," and rest upon the foundations. In heavy or main walls they must extend on both sides of the wall, and must project on each side to a distance equal to one-half the thickness of the wall. It is most important that foundations should be of the best material, as work is very apt to be scamped when hidden. Concealed parts of walls are similarly likely to be neglected, and therefore wainscoting, or lining with wood, is most undesirable in the tropics.

Damp-Proof Courses.—As water can rise in the house walls by capillary attraction to a height of 32 feet, it is essential that moisture interceptors be placed in them. These are called "damp-proof courses," and may consist of Portland cement, glazed stoneware, slates embedded in cement, or tarred bricks.

In a properly-constructed house one damp interceptor is required where the footing ends and the wall begins; a second, 6 inches above the level of the external earth; and, as damp may enter the wall from above, a third on the very top, beneath the roof timbers. If only one damp-proof course is feasible, it should be placed in the second position.

The inner or room walls of a house may be composed of bricks, tiles, or of wood and plaster.

The modern fashion of papering rooms in the tropics is to be deprecated. Paper is expensive, and cannot be often renewed. Moreover, one of the greatest enemies of the mosquito is the biennial colour-washing, which insures the brushing down of bungalow walls at least every six months.

All sharp angles should be rounded off, to facilitate cleanliness and prevent deposits of dust.

Walls should invariably be coloured in the lightest

shades, as we shall see that mosquitoes dislike all the lighter colours.

Chimneys.—The flues should be straight, circular, separate from each other, and smoothly lined, so as to prevent the risk of fires, facilitate cleaning, and aid the upward draught. All chimneys should rise at least 3 feet above the roof.

Roof.—There should always be an open space between the ceiling of the highest room and the roof. Tile roofs are very common in the tropics. They harbour rats, and thus tend to spread plague. The tiles are good conductors of heat, and in the absence of a properly-constructed ceiling and air space a room may be rendered absolutely uninhabitable by the heat radiating from a tiled roof.

Double roofs of non-conducting materials, and high rooms, are essential to comfort in the tropics. The heat radiated from a roof is in inverse ratio to the square of its distance. The direct heat reaching a person from a roof 5 feet above him is four times as much as would reach him if the roof were 10 feet above him. Ceilings should always be insisted on, as they act as powerful heat interceptors. The air space between them and the roof should always be ventilated.

Thatched roofs, consisting of palm-leaves or bundles of long wiry grass, laid on a bamboo frame, are very cool and dry ; but, unfortunately, they are very inflammable, and harbour squirrels, rats, insects, and other animals. Plantain fibre forms a good roofing material, and is not inflammable, but requires frequent repair.

Corrugated or galvanized iron is used as roof coverings in some parts of the tropics, but it is not to be recommended, as it renders the room excessively hot during the day, and cold at night. The iron sheets should never be laid on rafters only, but

should either be laid on or under the roof boards, or else lined with felt.

If the walls will stand it, a thick layer of mud over the sheeting is the best means of keeping off the heat of the tropical sun.

Floors.—Floors should consist of wood, bricks, tiles, slate, slabs, or concrete.

Concrete is the best and most sanitary of these materials, as it necessitates fewer gaps or cracks than any of the others.

The floors of many European residences and most of the native houses in the tropics are made of sun-dried bricks or rammed earth. It is impossible to keep a room clean with such a floor. The system of covering one of these floors with matting, and leaving it down for months without moving it, is comparable to the disgusting sanitary habits of the Middle Ages.

All floors should have a plinth of about 2 feet, to prevent dampness.

A well-constructed house should have drains to carry off water which drops from the eaves.

Mosquito-Proofing of Windows and Doors.—This consists in carefully protecting all windows and doors with fine wire gauze. The gauze may be tinned iron, copper, or brass, and must be secured with nails of the same metal to prevent galvanic rust.

This is an expensive measure, but it adds greatly to the comfort of life in the tropics. It excludes not only mosquitoes, but flies, moths, and other insects, bats, and birds.

Where, from the score of expense, mosquito-proofing with wire gauze is impracticable, ordinary cotton netting may be used. If painted four or five times with a solution of commercial silicate of potassium in its own volume of water, its durability is greatly increased, and it is rendered comparatively rain and fire proof.

Although high ideals are as yet impracticable in most tropical countries, the following eight simple rules can be carried out in the poorest dwelling and their observance should be insisted on by all health officers.

1. **Floors.**—Cow-dung attracts flies and moisture, and is a good breeding-ground for microbes, so that its use as a covering for room floors is most insanitary and must be abandoned.

Mud floors must have the surface dug up and removed at least twice yearly during the dry season.

Fresh mud must then be laid on, and beaten until quite smooth.

2. **Walls.**—These must be white- or colour-washed four times yearly, inside and outside.

3. **Windows.**—Every room must have two windows at least 2 feet square opposite each door, or one window 3 feet square opposite the door.

Windows must open to the outer air. They must be left open most of the day and all night.

4. **Cook-Room.**—A chimney or outlet for the smoke must be provided.

5. **Refuse and Waste Water.**—Refuse must be placed in a receptacle, and waste water emptied into a drain as far away from the house as possible.

6. **Latrines.**—These must be outside the general house buildings, and must have a window. They should have a solid floor, and must be easily accessible to the sweeper from behind.

7. Whilst a few plants and trees in the neighbourhood of a house are pleasant, there should be no interference with the free passage of the air and light to all parts of the dwelling, and all animals, fowls, and pets, must be separately housed outside the house and its enclosures.

Purdahs and hangings are to be avoided, as—"Where the sun does not enter, the doctor does."

8. Food should not be cooked in sleeping-rooms. A room used for cooking should be well ventilated; otherwise food becomes tainted and unwholesome from infected air.

6. Cooling of Rooms.

The following appliances constitute the means of reducing the temperature in tropical houses—viz.: (1) Punkahs; (2) Thermantidotes; (3) *khus-khus* Tatties; (4) Electric fans; (5) Jost fans.

1. **Punkahs.**—The punkah, much used in the tropics, consists of a framework of wood and canvas, having a deep fringe of matting, or composed of several layers of cloth. The arrangement is suspended from the ceiling, and swung backward and forward by a rope passing over a pulley, and worked by hand.

2. **Thermantidote.** — The thermantidote, already briefly referred to in Chapter II., is a machine through which, by the rotation of a wheel and fans, a current of air is forced into the room. It has the great advantage of not only putting air in motion, but also cooling it, through evaporation of moisture from thin, wet grass mats suspended in the short discharge funnel through which the air passes into the room.

3. **Khus-Khus Tatties.**—These consist of loosely woven mats made from the fragrant *khus-khus* grass. They are hung over windows and doors, and wetted frequently by pouring water over them. They are much used in India when hot winds are blowing. The rapid evaporation of water sprinkled on these mats effectually cools the interior of rooms.

4. **Electric Fans.**—These are by far the best of devices for cooling the air, and require no special description. They are very largely used in populous tropical centres, but are still rare in India outside the large towns.

5. **The Jost Fan.**—The Jost fan is now deservedly popular all over the East. It consists of a small motor driven by an ordinary kerosene lamp, which works a fan. The apparatus is portable, and does not get out of order readily.

The custom, formerly popular in the tropics, of avoiding the extreme heat of the summer by living underground is, happily, disappearing. Cellar rooms, although convenient, are dark, ill-ventilated, and unhealthy.

7. Lighting.

The agents employed in the tropics are sunlight, candles, oil, coal gas, and electricity.

No house is healthy unless sunlight has access to each room.

Candles.—As found in the tropics, these are almost invariably composed of stearin. The products of combustion are watery vapour and carbonic acid, and two sperm candles foul as much air as one man. They are comparatively feeble illuminants, but in themselves produce little or no ill effects on the health.

Oil.—The chief illuminating oil is kerosene. It consumes oxygen of the air to a greater extent than candles, and gives off watery vapour and carbonic acid. A good oil-lamp of moderate size is, as we have seen, equivalent to seven men in its power of rendering the air impure. Weight for weight, kerosene-oil is twice as powerful an illuminant as candles. Inferior oils are liable to ignite and cause fire, and therefore their use for bathroom lamps and similar purposes is a most dangerous form of economy in the tropics.

Coal Gas.—This, the most widely used illuminant in Europe, is comparatively little used in tropical lands. It possesses many disadvantages, being

poisonous and explosive, whilst it renders the air impure. It is, however, a cheap and fairly powerful lighting agent. One gas-jet fouls as much air as five or six men, but the introduction of the incandescent burner renders the light more brilliant for a smaller consumption of gas, and consequently diminishes the production of impurities, uses up less oxygen, and produces less heat.

Acetylene Gas.—Acetylene, the chief illuminant in coal gas, is evolved when water comes into contact with carbide of calcium. It is colourless, has a strong odour, and can be stored in gasometers and burned in special lamps. It easily explodes when mixed with air in a proportion of 7 per cent., but is only very slightly poisonous. For household use, improved apparatus for its combustion is required, as at present lamps have to be recharged with carbide frequently, and the process is both difficult and offensive.

Petrol.—A large number of lamps are now in use which burn petrol. They give a brilliant white light of great intensity. Petrol gas installations have recently been fitted up in many clubs in various places in the tropics. These give little trouble, and are both economical and sanitary.

Electricity. — From a hygienic point of view, electric light is the best illuminant for tropical use, as it has none of the disadvantages of the other forms of lighting. It does not vitiate the air, deprive it of oxygen, nor yield to it carbonic acid, watery vapour, or much heat; while it is clean, and does not discolour the walls or ceilings.

When dealing with sanitary authorities in the tropics, the following statement by two eminent Indian doctors may be usefully quoted when a desire is displayed to postpone indefinitely some sanitary reform :

"No amount of expenditure upon greater cleanliness and better sanitary provisions can ever compare with the advantages accruing to the people from the inoculation of a clearer conception in them of the advantages of *household cleanliness*, and the blessing of good health resulting from sanitary surroundings."

CHAPTER VII

THE DISPOSAL OF REFUSE IN THE TROPICS

As the ordinary water-carriage system of Western countries only exists in the Presidency capitals of India and in a few seaboard towns, we will deal only with the following methods of disposal of excreta in the tropics—viz. :

1. The dry system of conservancy.
2. The wet system of conservancy.
3. Incineration.
4. The biological method of sewage treatment.

1. The Dry System of Conservancy.

Latrines usually consist of corrugated iron sheds with partitions of the same material. They are fitted with glazed earthenware dishes or tarred or enamelled iron pans, into which urine and fæces are passed, the contents being emptied into receptacles and removed daily, by means of iron carts, to a pieee of ground outside the town, where it is deposited in shallow trenches and covered with earth.

Latrines should always be placed on an impermeable base, made of concrete ; and whatever variety of latrine may be adopted, the following points should always be borne in mind :

1. The sun's rays must be brought to play upon the whole of the inside of the latrine for as many hours in the day as possible.
2. Free ventilation must be provided.
3. Rain must be kept out.
4. Privacy must be maintained.

The ground used for trenching is cultivated, and rich crops of jute, cabbages, sugar-cane, maize, etc., are grown. Under proper European supervision, trenching grounds give little trouble and are quite sanitary, but those under the control of some tropical municipalities are too often entirely neglected, with the result that the improperly-cared-for trenches and conservancy carts become regular fly nurseries, and the system is the cause of grave nuisances and danger to health.

The cardinal principle to be observed is that filth, refuse, and all other putrescible matter, etc., must not be exposed to flies or be allowed to contaminate the ground, but quickly and securely transported and disposed of.

Water-tight receptacles for night-soil and water-tight filth-carts must be provided, and the process of removal carefully supervised from start to finish.

A system of removal by day must be adopted, as night removal leads to many abuses.

The trenching grounds must comply with the following requirements: (1) Suitability of soil; (2) presence of irrigation; (3) suitability of distance from barracks and inhabited areas; (4) a succession of quick-growing crops; (5) sufficient ground to insure that each plot is only trenched once in four years, so that the soil may not be overcharged with manure; (6) facilities for thorough cleaning of all filth-carts and receptacles taken to the ground.

All the arrangements of the trenching ground must be reduced to a system that leaves nothing to chance, and provides that all trenches are ready at least twenty-four hours before they are required.

A due proportion of sanitary plant to be used in lieu of articles under repair, and for emergent calls on the conservancy system, must be provided.

The objection to seeing fifth-carts plying by day

is more or less a sentimental one, but working hours should be so fixed as to cause the least amount of inconvenience to the public. Filth-carts need not be offensive if they are properly looked after. They will be odourless if the proper lids are provided, and thorough cleansing takes place after each visit to the trenching ground.*

The defects in this system are two in number :

1. The first is the fact that fæcal matter, dirty buckets, receptacles, etc., are left exposed for many hours at a time, open to the air and accessible to flies. There is no doubt, as will be shown in Chapter IX., that the ordinary house-fly plays an important part in the dissemination of some diseases in tropical climates ; and the more opportunity this insect has of gaining access to human discharges, the greater the danger to the health of the community.

Where practicable, some modification of the pail system should replace the system of receptacles and fifth-carts, as nuisance caused by night-soil increases in direct proportion to the amount of handling that is necessary.

2. The second flaw in this method is that it involves the use of dust-laden latrines, as it is obvious that the dry-earth latrine renders every facility for enteric fever "carriers" to perform their baleful function of spreading the disease.

Latrine infection is a most potent factor in the causation and spread of enteric fever in the tropics. Every sanitary officer has from time to time to deal with epidemics where the water-supply is above suspicion, and where, after eliminating every possible known cause, it is satisfactorily established that the seat of infection has been the latrine or urinal.

* Trenches should be 9 to 12 inches deep. If deeper, proper destruction of fæcal matter does not occur ; if more superficial, flies may hatch out and burrow their way to the surface.

2. The Wet System of Conservancy.

As carried out until quite recently in India, there can be no sort of doubt that hand removal of dejecta was fraught with great difficulties, and accompanied by nuisance, soil pollution, and danger to health, at every step. That the use of the earth system is in itself a menace to health is evidenced by military statistics, which show the much lower incidence of enteric amongst officers, women, and children, using commodes than amongst the rank and file obliged to use earth latrines, the atmosphere of which may be polluted with typhoid-laden dust.

Recognizing these objections, what is known as the "wet system" of conservancy has been introduced, which is directed against pathogenic bacilli present in ordure by the inhibition of their action or their destruction by means of disinfectants.

This system may be carried out with either a coal-tar disinfectant, such as saponified creasol, or a solution of perchloride of mercury.

The solution is placed in the receptacle, and in some places a small iron skewer with a flattened end is provided to disintegrate large lumps of material, so as to allow the solution to reach every portion of the dejecta.

Urinals are fitted with a receptacle which has a small hole in the bottom sufficient to allow the solution to fall drop by drop at the head of the trough.

Strong statistical evidence has been adduced to show that wherever the "wet system" has been introduced the enteric fever incidence has gone down.

Anyone who doubts the benefits of the "wet system" has only to visit latrines in which it is working, and others where either the so-called "dry earth" or the litter modification of the Goux system,

used in connection with incineration, is in vogue. In the former flies will be few or absent ; in the latter they will be found in large numbers at all times of the year.

Whether carried out by dry or wet methods, the hand-removal system is not economical from a financial point of view. It necessitates a large staff of sweepers, many carts, bullocks to pull the carts, and a very heavy incidental expenditure. The wear and tear of carts, buckets, etc., is enormous, and the difficulty of getting repairs done to conservancy appliances is well known.

The appreciation of some of these difficulties led to the introduction of the next system.

3. Incineration.

As far back as the Crimean War, British troops burnt their camp offal in improvised incinerators, built much in the fashion of limekilns ; but of recent years disposal of refuse by burning has been advocated as a novelty, and taken up with great enthusiasm by many sanitary officials.

A vast number of incinerators or apparatus for burning excreta have been devised and given special names, but all of them may be divided into two classes —viz. : (1) Slow combustion ; (2) rapid combustion.

1. The type of the former variety is one which consists of a circular iron framework without sides, and with or without an iron cover.

The incinerator is set going by placing a quantity of litter and dry refuse on the framework and setting fire to it.

When combustion has proceeded for some time, the total contents of latrine pans are emptied over the smouldering material. In our experience, heavy rain invariably puts these incinerators out, and the exposure of smouldering material to the strong gales

which are not infrequent in tropical countries must, and does, result in the addition of much objectionable matter to the dust which is blown in all directions.

2. The second variety aims at some kind of forced draught, with the enclosure of the material inside a brick or metal furnace. There can be no doubt that this type is a better form of incinerator. The objections indicated under the first variety are not present; waste matter is more completely and more quickly consumed; and the actual cost of construction—an important matter in municipal institutions—is not greater. In this form a further improvement is aimed at—namely, a mixture of fluids with some dry material which will absorb it and promote ready combustion. This desideratum is obtained by mixing with dry leaves, litter, wood shavings, coaldust, or sawdust.

A method which has been used of recent years—viz., the placing of stable litter in the receptacles—cannot be recommended, as the litter undoubtedly attracts flies.

The following conditions for the proper incineration of night-soil are absolutely essential if the method is to be a success:

1. A properly-designed incinerator.

2. Constant intelligent supervision and efficient stoking.

3. A liberal supply of fuel.

4. A mixing platform provided with a roof and a storage go-down for the combustible material in wet weather.

If any of these four conditions are absent, the process sooner or later breaks down.

1. **Proper Design of the Incinerators.**—The great mistake of most types of incinerators is that the draught is not sufficient; the consequence is that there is a great deal of smoke, which is often highly offensive. The presence of smoke is nearly always due to one

of two things: (1) Defective design of the incinerator, or (2) insufficient supply of dry and inflammable material.

2. **Supervision.**—Constant supervision is necessary, because the native sweepers neither know how to stoke properly nor the best means of mixing the night-soil with the inflammable material. They are always sparing with the fuel. If left to themselves, they almost invariably put the mixture into the incinerator either too wet to burn or too much of it at a time, so that the fire smoulders and much smoke is generated.

3. **Fuel.**—In order to burn night-soil, a large quantity of combustible material is required. The best materials are wood shavings, sawdust, coaldust, damaged bhoosa,* or pine needles.

The greater the amount of combustible material that is mixed with night-soil, the less the smoke and the possibility of nuisance. If any of these materials have to be purchased in the open market, the incineration of night-soil cannot be carried out economically. Consequently an insufficient supply of fuel is used, the night-soil is imperfectly incinerated, and the nuisance arising from the incinerator is often great.

The rubbish that is collected during the rains in any part of the tropics will not burn; therefore, if stable litter is to be relied on for incineration of night-soil, a quantity of dry material must be stored for use in wet weather. This is certainly not a sanitary proceeding unless the material is issued thoroughly dried from a central store.

The method in use with incinerators in India is a form of the Goux system. A modification of the method of sewage disposal still in use in various French towns, and at Halifax in Yorkshire, was introduced at Dagshai in 1901, and fully described in a paper by the author.

* Chopped straw, largely used as fodder in India.

The Dagshai plan was to mix pine-needles with both liquid and solid excreta, and was therefore only applicable to certain hill stations; but the method has been made applicable to plain stations by adopting stable litter as the absorbent material. This involves the carting of litter into bungalow compounds.

The introduction of stable litter into compounds is obviously objectionable, seeing that horse-droppings are, as will be seen from Chapter IX., the favourite breeding-ground for flies, and that these insects are now regarded as hardly less important than mosquitoes as disseminators of disease. The greatest care should therefore be exercised to prevent the smallest quantity remaining any length of time without being passed through the incinerator. Moreover, it is necessary to see that the manure is destroyed, and not merely toasted, as is sometimes the case.

4. **Fuel Sheds and Mixing Platforms.**—In a heavy downpour of tropical rain it is impossible to keep any material, be it sawdust, wood shavings, or litter, in a readily inflammable condition. Therefore it is necessary that shelters should be provided for any mixing procedure adopted and for the storage of fuel.

When litter is used in incinerators, fuel sheds often constitute a grave nuisance, as they develop into veritable fly nurseries.

Fuel sheds should only be large enough to contain two days' supply of fuel, surrounded with wire gauze which will admit of drying and exclude flies, and, most important of all, provided with concrete floors.

The difficulties with reference to incineration may be summed up under four headings:

1. Disposal of fluids.
2. Supervision of stoking.
3. Æsthetic.
4. The supremacy of the scavenger.

1. **Disposal of Fluids.**—The point with reference to incineration which appears to be debatable is the disposal of fluids.

It is calculated that 240 pounds of coal or 960 pounds of wood would be required to evaporate the total amount of urine from 1,000 persons per diem. It would therefore appear that, if complete destruction of fluids is really achieved in incineration, stable litter and refuse constitute a fuel of higher economic value than is generally supposed.

In practice, the evaporation of fluids is not really carried out, the fluid excreta being tipped into a drain or soaking into the soil beneath the incinerator.

2. **Stoking.**—The success or otherwise of incineration depends on effective stoking or the individual technique of the sweepers. Obviously it is easier to throw away fluids than to burn them, and if not constantly looked after they are likely to adopt this simple solution of a difficult problem.

3. **Æsthetic.**—A serious æsthetic objection to incineration is the smell and smoke associated with it. These are undoubtedly nuisances, and it has recently been shown that this objection has more than an æsthetic foundation, as, in stations where this system has been introduced, the prevalence of sore throat is attributed by some observers to incinerator smoke.

The appearance of the incinerators, with their unsightly sheds containing heaps of litter, is hardly less objectionable than that of the indescribably foul conservancy carts.

4. **The Supremacy of the Sweepers.**—The gravest of all defects in this method is that, whilst in other systems the sweeper is important, in the practice of incineration he stands supreme, and the whole of the conservancy arrangements of a community depend on the goodwill and behaviour of the sweepers. This is a very great weakness. The entire sewage

disposal of a town may be upset by a strike amongst the scavengers, which not only causes great inconvenience to everyone concerned, but endangers the health of a whole community.

The Cost of Incineration.—There can be little doubt that the introduction of incineration produced a considerable saving of funds, and that it was largely the claim of its advocates, that it could be carried out for next to nothing, that commended it to many authorities.

We are inclined to think that the original savings were due to cheap and inefficient incinerators, cheap sheds, and imperfect fuel, which have succeeded in bringing the system into considerable discredit. When carried out with the proper apparatus and fuel, it is more than doubtful whether incineration will be much cheaper than trenching.

4. Biological Treatment.

This system of sewage disposal consists of the reception of sewage in what are known as septic tanks. It is a variety of water-carriage system, and a liberal allowance of water is essential for its installation.

Its advantages may be summed up as follows :

1. It is cheap.
2. It requires a very small staff to work it.
3. It places all putrescible matter out of the reach of the omnipresent fly.

The sewage is flushed by water from a suitable latrine into a long, thin closed tank, varying in size with the number of individuals who are to use the latrines connected with it. The most economic and satisfactory working depth for a septic tank is 6 feet, but 5 feet does fairly well, and may be used in places where, on account of the latrine being used in rushes, as at railway-stations, very ample seating accommodation is required, with a comparatively small tank capacity.

In most active septic tanks there is about 8 to 12 inches of light sludge, and the scum is frequently some 6 inches in thickness, so that it is, obviously, not desirable to reduce the depth below 5 feet.

A tank capacity of 12 to 15 gallons per user per diem gives the best results. A grit chamber must be provided for the collection of solid material and its removal.

When the sewage enters the tank, a leathery scum forms on the surface, from 2 to 6 inches thick ; below this is the zone of fermentation, in which the sewage is clear, but permeated by bubbles of gas that constantly rise to the surface and maintain a quiet movement throughout the whole body of the fluid. At the bottom is a small layer of peaty material. Small pieces of organic matter sink by their own weight, but on reaching the bottom gas is evolved from their constituents by bacterial agency, and the particles are floated up again ; on reaching the top the gas bubbles burst, and the solid matter again sinks. This cycle is repeated until practically the whole of the suspended solid material is liquefied through bacterial action.

With a tank working properly sludge accumulates very slowly.

It is drained off at rare intervals into a pit filled with gravel and stones.

The fluid part of the sludge soaks away into the subsoil ; the sludge itself, which is quite odourless, is removed and trenched.

The fluid sewage after treatment escapes by means of pipes at a point halfway between the scum and sludge.

Septic tank effluent must always be looked upon as potentially dangerous. Houston's conclusion, that "the effluents from bacteria beds ought to be regarded as hardly, if at all, more safe in their possible relation

to disease than the raw sewage before treatment," has been accepted unchallenged by sanitarians generally. Therefore the passing of septic tank effluent, however good in quality, into a river from which a large proportion of a population of a town draw their drinking water cannot be tolerated.

The most satisfactory of all methods is the passing of the effluent over land.

The next best method to disposal on land is discharge into the sea or large stretches of water, and the worst of all is to discharge it untreated into a stream.

The difficulty in the way of installing the water-carriage system in the tropics prior to the introduction of this method has been that no suitable place for disposal of the sewage could be found without making the whole neighbourhood insanitary. The proper use of the septic tanks does away with this important objection, as it is possible to convert the sewage into a clear, non-putrescible and odourless effluent, which can safely be treated over land, or, if it is sterilized, pass into a stream.

Disposal of Household Refuse.

The effective disposal of town waste, consisting of household refuse, paper, rags, and other more or less combustible material, constitutes one of the greatest difficulties which those responsible for the public health in the tropics have to face. The difficulty is increased by the fact that the material to be dealt with varies in quality and quantity according to season, the kind of fuel used, and the habits of the people.

In the tropics it is especially accentuated by the national habit of using the street as a depository for filth and waste.

One has only to visit any city or village in the tropics, and wait for a few minutes, to see quantities of rice and other food material thrown out of the windows; whilst the odour of the drainage channels are eloquent testimony that both liquid and solid ordure has been thrown into them from the housetops.

The magnitude of this problem of refuse disposal is apparent when we realize that, for urban areas, the quantity of ashbin refuse averages from 150 to 190 tons annually for each 1,000 inhabitants.

A proper system of scavenging is, therefore, the ABC of sanitary administration in the tropics. Waterworks, drainage schemes, etc., are admirable things in their way, but till people of the tropics have appreciated the necessity for domestic and street cleanliness, they must be to them as learned books which they are often called upon to master before they have acquired the alphabet of sanitation.

We insist, therefore, that amongst populated centres in tropical latitudes cleanliness and freedom from refuse matters of all kinds are the first essentials to the public well-being.

By the expression "town refuse" is understood what may be described as domestic household refuse, with in most cases some limited admixture of trade and shop rubbish, and in many districts a small proportion of vegetable or garden waste. The chief methods employed for the disposal of such materials from towns may be briefly summarized as follows:

1. **Depositing upon Waste or Low-lying Land, filling up of Pits or Excavations, or raising the Level of Marsh Land.**—This method often gives rise to intolerable nuisance, and is only mentioned to be unhesitatingly condemned. Too often made soils are, as we have seen in the last chapter, used as building sites, with disastrous results.

2. **Selling by Tender Yearly.**—As town refuse is found to be a good top dressing for the production of grass, it will sometimes command a sale. This method commends itself to municipal authorities, as it enables them to get over a great difficulty without expense, and even with profit; but it is not to be recommended, as the contractor is very often dilatory and unsatisfactory in carrying out the process of removal.

3. **Destruction by Fire.**—This is far and away the best method, but the method of disposal in different districts has hitherto depended largely on local circumstances and conditons, the cheapest plan available having always the preference in the tropics. Oftentimes this may be but a mere makeshift, and the means of disposal for many years may be nothing better than a hunting about from one makeshift to another, until at last, all other means having been exhausted, a refuse destructor becomes an absolute necessity.

Given a good destructor and proper management, town waste and house refuse can be reduced to about one-third their original bulk, the residue being innocuous clinker, metallic refuse, and dust.

The adoption of incineration of excreta has the advantage of rendering the disposal of other refuse comparatively easy, as destructors—of a kind—are always available.

Proper receptacles for refuse should be provided by all tropical municipalities. They should be small, covered, and made of some kind of metal, so as to be unabsorbent, and they must be emptied at least once daily.

CHAPTER VIII

DISPOSAL OF THE DEAD

WHEN it is realized that in India alone the number of deaths annually is over 8,000,000, and that of these over 150,000 die of smallpox, and perhaps another million of other infectious diseases, the disposal of the dead is one of the most important matters to be dealt with in tropical countries.

The following methods of the disposal of the dead are in practice in the tropics :

1. Burial in its various forms.
2. Cremation.
3. Exposure.

1. **Burial.**—From long-established custom, and also for sentimental and religious reasons, both Christians and Mohammedans prefer to bury their dead. Amongst Indian Mussulmans the practice is more sanitary than amongst Christians, as coffins are not used. Much has been said and written against burial as a method of disposing of the dead.

Seymour Haden has shown that, if carcasses are covered by a foot of suitable earth, the perishable parts disappear inoffensively within twelve months. The efficiency of earth burial varies directly with the depth, and, speaking broadly, it may be said that for every foot of depth below the soil about one year is necessary for resolution. The present practices, however, and even the laws, in temperate climates,

are inconsistent with burial sufficiently shallow to permit of the due action of the nitrifying organisms, which are found only in the upper layers of the soil. The objects of earth burial are still further frustrated by the still prevalent use of metallic or heavy wooden coffins.

Cemeteries.—The three chief sanitary considerations to be held in view in the provision of burial-grounds are—(1) Suitable soil and proper elevation of site ; (2) suitable position, especially with respect to houses and sources of water-supply ; (3) sufficient space (*vide* L.G.B. Memorandum, 1906).

(1) *Soil.*—The objects to be aimed at in burial are —(*a*) Rapid resolution ; (*b*) complete oxidation or absorption of the products. Hence the soil of a cemetery should be light, open, porous, and either naturally or artificially drained to a depth of not less than 8 feet, so that air and moisture may pass freely. Loam or sandy mould is about the best soil ; clay is difficult to drain, retards decomposition by excluding air and moisture, and either retains the products of decomposition or allows them to escape through fissures. A loose, stony soil allows gases to escape too freely.

(2) *Position.*—It is desirable that burial-grounds should not closely adjoin dwellings. While convenient of access, they should, therefore, be placed outside the limits of probable future building. The surface should not be grassed. Cemeteries should not be placed on elevated ground whence the natural drainage may find its way to dwellings below or contaminate a water-supply. For obvious reasons, lands liable to floods, or encroachment by streams or by the sea, are unsuitable.

(3) *Space Required.*—It is usually estimated that an acre of ground is a minimum allowance for a population of a thousand persons for fifty years.

In India bodies should be buried deep enough to prevent jackals, pariah dogs, and other animals, from digging them up and feeding on them. Heavy flat stones may have to be placed under the surface of the ground to prevent this, or bodies buried in a sort of vault built of stones or bricks. This procedure, of course, delays decomposition, but is much more sanitary and seemly than having the body dug up by these foul animals.

Cemeteries require frequent inspection to prevent such desecration of the dead and the resulting danger to the public health.

There appears to be no doubt that overcrowded cemeteries, such as are very common in the tropics, exercise a bad effect on the health of the communities in the vicinity.

This prejudicial effect is exercised in one of the following ways :

(1) Contamination of the air by effluvia.

(2) Contamination of neighbouring local water by products of decomposition, such as $(NH_4)_2S$, H_2S and NH_3.

(3) Contamination of wells by specific micro-organisms.

The last two sources of danger are dealt with very ably in a L.G.B. Memorandum issued in 1880.

2. **Cremation.** — This method as practised in Western countries is unquestionably the best method of disposal, as in a crematorium of modern construction a body of average weight is reduced to about 3 pounds of inorganic ash within two hours. The fuel employed is coke, coal, or gas. In either case a ventilating shaft with pilot fire at its base is necessary. The chief objections to cremation are—(1) That the soil is deprived of the organic matter that would otherwise be returned to it ; (2) that it involves an unnecessary waste of the world's limited stock of

combined nitrogen ; and (3) that the impossibility of exhumation may increase the facilities for concealing homicide. The first objection has no great weight at present, since little attempt is made to utilize burial-grounds for cultivation. The last is, however, more serious, and cannot be regarded as satisfactorily met by the proposition for a minute and detailed autopsy in every case. The discovery of organic disease would not necessarily exclude the possibility of foul-play, and an examination sufficiently detailed to exclude every known poison is obviously impracticable. Exhumation is rarely resorted to, but the possibility of it acts as a check upon crime.

As practised by the poorer classes of Hindus, however, cremation is by no means a good plan of disposal of the dead. Fuel is expensive, and very often the dead Hindu is taken to the burning *ghat*, and his face merely burned with fire ; the body is not burnt thoroughly because of the poverty of the relatives or the greed or dishonesty of the people paid to carry out the cremation.

The partially charred body is usually thrown into a river. If the deceased has died of a disease such as cholera, the danger to riparian villages and towns are obvious.

3. **Exposure.**—In some parts of the tropical world bodies are simply exposed to the elements, and their ultimate disposal left to scavenging birds. The *dakhmas*, or towers of silence, of the Parsees have frequently been described, and are looked on with something like horror by Western people ; but they are far from being insanitary, and have never been shown to spread infection.

The platform on which the dead are laid is lined with marble or concrete, and channels are provided for the collection and disposal of fluids which may escape from the bodies.

The corpses are picked clear of flesh in a period ranging from a few hours to a week.

The dry bones are then placed in a large pit, where they gradually undergo resolution into a fine impalpable powder.

This method, though contrary to European and even most Oriental sentiment, is well adapted to the tropics, as it is rapid and effectual.

The favourite method of Eastern criminals of disposing of the bodies of their victims is to throw them down a well—preferably, of course, one not in use. Dead bodies of animals are frequently disposed of in the same way, but more often they are deposited on the village refuse-heap, producing one of the most offensive of many insanitary abominations to be seen in the vicinity of tropical towns.

CHAPTER IX

INSECTS AND DISEASE

Insects may be the agents in the transmission of both (1) bacterial and (2) protozoal diseases.

1. **Bacterial Diseases.**—In the dissemination of diseases caused by bacteria, insects were formerly thought to act as passive agents.

It was taught that they conveyed infection by taking up the specific material on their wings, legs, proboscis, and body, and depositing it on the food or water-supplies of man; but it has recently been shown that flies which have access to tuberculous sputum retain the tubercle bacilli in their digestive tubes for several days, and that the tubercle bacilli multiply there more rapidly than in cultures. Furthermore, it is obvious that the fly can act as a vehicle; and though it does not itself become tuberculous, its digestive fluids appear to be a favourite medium for the cultivation of the tubercle bacilli.*

Still more recently it has been shown that the fly also takes the *Bacillus typhosus* into its intestines, and that the bacillus can exist there for eleven days.

The house-fly, before sucking material, moistens it with a fluid which it ejects from its proboscis; and it is this fluid, when infected by bacteria, which is more dangerous and more lasting as a means of conveying disease than the mere mechanical method of carrying microbes on the exterior of the fly's body.†

* Andre, L., C. R. Soc. Méd. Hôp. de Lyon (1906).

† Graham Smith in Local Government Board Report, new series, No. 53.

2. **Parasitic Diseases.**—In the transmission of animal parasites, insects may be (1) merely passive agents, as in the case of the flies of various kinds; (2) intermediaries, as in the case of mosquitoes and sand-flies; and possibly also (3) active agents, as in the spread of yellow fever by *Stegomyia fasciata*.

The following is a list of injurious insects, and the human diseases they are known, or supposed, to transfer:

1. *Formicidæ* (*Ants*).—May readily convey all the diseases due to contamination of food, such as cholera, dysentery, and enteric. There is no definite proof that ants act as carriers, but, considering their habits in tropical countries, it is far from unlikely.

2. *Cimicidæ* (*Bed-Bugs*).—Charged with the conveyance of anthrax, kala-azar, leprosy, some skin diseases, tuberculosis, typhus fever, and yaws.

3. *Siphonaptera* (*Fleas*).—Plague.

4. *Muscidæ* (*Non-biting Flies*).—Anthrax, eye diseases, cholera, diarrhœa, dysentery, enteric fever, myiasis, leprosy, skin diseases, tuberculosis, Oriental sore, and yaws.

5. *Muscidæ* (*Biting Flies apart from Mosquitoes*).—*Glossina palpalis*, a tsetse, conveys sleeping sickness.

6. *Chironomidæ* (*Midges*).—Pellagra and anthrax.

7. *Culicidæ* (*Mosquitoes*).—Malaria and yellow fever.

8. *Phlebotomi* (*Sand-Flies*).—Three and seven day fevers, and tropical sore.

In addition to the insects proper, a large group of members of the *Arachnidæ* or *Spider* family act in a similar way, notably—

1. *Sarcoptes Scabei*.—In addition to causing the disease known as "itch," is charged with conveying leprosy and skin diseases.

2. *The Ixodidæ*.—These pests are the agents for the conveyance of a large number of diseases of animals, and it has recently been shown that in

Africa they convey the germ of a fever which closely resembles relapsing fever—a discase now known to be conveyed by ordinary pediculi.

The insects constitute a zoological class divided into numerous orders and families. The orders represented by the families above referred to are—

1. The Diptera, including flies of all kinds.
2. The Hemiptera, including bugs.
3. The Anoptera, including lice.
4. The Siphonaptera, including fleas.
5. The Hymenoptera, including ants.

The face mite, itch insect, and the ticks, are not insects, as they possess eight legs instead of the six which are characteristic of the insects. They belong to the same family as spiders, mites, and scorpions.

The bodies of insects are covered with a tough skin, and are divided into three distinct parts : (1) The head, provided with two antennæ, or horns, and eyes and mouth of variable form ; (2) the thorax, composed of three segments, which has underneath it always six articulated limbs, and often above it two or four wings ; and (3) the abdomen, composed of nine segments, some of which may be difficult to recognize.

In addition to these characteristics, they are not provided with interior skeletons, and the nervous system is formed of a double cord swelling at intervals, and placed under the head and along the underside of the body. Insects are not provided with lungs, but breathe by particular organs, termed "tracheæ," extending parallel to each other along each side of the body, and communicating with the exterior air by lateral openings termed "spiracles." The sexes of all insects are distinct, and are reproduced from eggs. Finally, in many cases the different parts we have mentioned are not complete until the tiny creature has passed through the following four stages, called " complete metamorphosis " :

1. The egg stage, in which the insect usually attracts no attention.

2. The larval stage, in which it is most destructive as a maggot, grub, or caterpillar.

3. The nymph stage, in which the insect again becomes inoffensive.

4. The imago, or stage of full development.

THE DIPTERA.

This order is characterized by—

1. A single pair of membranous wings.
2. A suctional mouth.
3. Complete metamorphosis.

The members of this order with which we are concerned are divided into three groups :

1. Group A : Containing mosquitoes, sand-flies, and midges.

2. Group B : Containing the great family of house-flies.

3. Group C : Containing the large family of horse-flies.

Group A.

General Characteristics.—Flies with slender bodies and long antennæ, which are often plumed.

The group includes the most important disease-transmitting insects—viz., mosquitoes, sand-flies, and midges.

1. **Culicidæ.**

Family Characteristics.—(1) A proboscis ; (2) scales on wings, head, thorax, and abdomen ; (3) venated wings. No other flies except Psychodidæ have scales on their wings, and the short proboscis of the Psychodidæ, as well as their general appearance, is quite distinctive. Chironomidæ, which are much like mosquitoes, have not got a long proboscis.

Tribes or Subdivisions :

(1) Culicinæ.

(2) Anophelinæ.

The first three stages of all varieties are spent in the water, the last only on the wing.

(1) *Culicinæ.*

Life-History—The Imago : Male.—Antennæ plumose, palpi prominent.

Female.—Antennæ shorter than proboscis and have only short lateral hairs. Head scales: (1) Narrow curved; (2) upright forked; (3) laterally few flat scales. The scales on the wings head, and body, have frequently characteristic shape in the different species and genera, and are therefore used in classification.

The head contains organs of sense and a brain.

The chest is chiefly filled with muscles which move the legs and wings, and the abdomen contains the more important organs of digestion.

The legs are made up of hips, thighs, shanks, and feet, and the tip of each foot is a sharp-pointed claw.

The wings are generally larger in the female than in the male, and vary greatly in colour. They may be brown, grey, or greenish-black, and have scales with various delicate markings, utilized to distinguish the different species.

Eggs.—To deposit her eggs, the insect alights on a floating fragment in weedy, stagnant water, forms her hind-legs into a receptacle, and drops her eggs one by one on to it.

The eggs are oval in shape, and about 1 millimetre in size, surrounded by a gelatinous material which binds them together. They adhere together in little raft-like colonies, containing two or three hundred eggs, which float on the surface. Found in artificial collections of water.

Larvæ.—In about three days the eggs open by a sort of trapdoor near the larger end, and the larva, which is just big enough to be macroscopic, comes out under water. From the first it swims about actively.

It consists of a head with two very large eyes, a globular thorax, and an abdomen of nine segments.

The last two segments of the abdomen are of curious construction. The eighth bears gill processes, and the ninth is prolonged upwards into a breathing tube or siphon, at whose summit the tracheæ open.

The end of the tube is surrounded by a fringe of fine hairs, which prevents it from sinking, and the opening of the tracheæ from being submerged. The culicine larva spends a considerable part of its life thus suspended by its siphon fringe to the surface film of the water, but if frightened or desirous of feeding at the bottom it can shut up the fringe, and its own weight then causes it to sink.

The larva is very voracious, and is continually on the move in search of food, which consists of small aquatic plants and animals.

The larva is preyed upon by small fish, and, to avoid its natural enemies, has a great predilection for aquatic weeds, which provide it with grateful protection. It sheds its skin two or three times, and grows rapidly.

Nymph.—The change from larva to pupa is very rapid. The full-grown larva swims about in a fitful, purposeless way, and finally comes to rest. It then sheds its skin and emerges as the perfect nymph.

The pupa or nymph is a comma-shaped creature with long narrow siphons projecting from the posterior portion of the thorax.

When about two or three days old, the nymph case, which is at first light in colour and difficult to see, develops *silvery patches*, due to bubbles of air underneath them, then splits, and the perfect insect

emerges from it. It raises itself on its legs, withdraws its wings, and, standing on the buoyant pupa case, lifts itself well into the air and, when its wings have sufficiently hardened, flies away.

Stegomyia.—A variety of Culicinæ. They have the following scales on the head :

1. No narrow curved scales.
2. Few forked upright scales.
3. Flat scales covering whole of head.

The *Stegomyia fasciata* is the carrier of yellow fever.

(2) *Anophelinæ.*

The members of this tribe constitute the malaria-carriers. Only the following tropical varieties have been shown to carry the disease :

North America : *A. maculipennis.*

South America : *Cellia albipes* (West Indies), *Cellia argyrotarsis* (Brazil), *M. lutzi* (zygotes).

Africa : *M. funesta, P. costalis, A. maculipennis, A. algeriensis, M. hispaniola* (the last three in Algeria), *Cellia pharoensis* (zygotes).

India : *M. listoni, M. culicfacies, N. fuliginosus.**

Imago.—Sex distinguished as with Culex.

Proboscis straight, and palpi as long, or nearly as long, as proboscis.

These two characteristics are present only in female anophelines. Wings spotted in most varieties.

Eggs.—Readily distinguished from Culex, as they are found separately on surface of water, or arranged in triangles or other geometrical figures. Boat shaped, ribbed laterally. Found in natural or terrestrial collections of water.

Larva.—Attitude on surface of water is characteristic.

* Christophers says this list may be extended on circumstantial but not on demonstrative evidence.

An anopheline larva, instead of lying with its head and body sloping downwards beneath the surface in an oblique direction, lies flat at the surface, nearly the whole of its body lying parallel to and touching the surface film. There are two reasons for this attitude—namely : (1) Anopheline larvæ do not possess the characteristic air-tube of the Culicinæ ; and (2) on the upper surface of the abdominal segments are little cup-shaped structures called "palmate hairs," which open at the surface of the water, and, acting like floats, keep the body of the larva in contact with the surface. These palmate hairs can be easily seen by examining in a drop of water under a low power of the microscope. They are not present in the larva of any other kind of mosquito, and, together with the straight and short air-tube, render anopheline larvæ easy to recognize.

Nymph.—It is not easy to distinguish anopheline from Culex nymphæ, but the matter is not important.

The Biting Parts of the Mosquito.—The organ of special interest to the health officer is the proboscis of the anopheline.

It differs considerably in the male and female.

The Female.—It consists of gutter-shaped lower lip (the labium), roofed in by the upper lip, composed of labrum and epipharynx, so as to form a complete sheath and support for the inner parts. These consist of a flattened, blade-like "hypopharynx," or tongue, and four sharp serrated needles—the two mandibles and maxillæ. It is these last six parts of the organ which do the actual work of piercing and sucking. The epipharynx and hypopharynx form by their approximation a central tube through which the blood is sucked.

The labium does not pierce the skin at all, but can be seen to bend so as to allow the labrum to be inserted to a satisfactory depth.

Attached to the end of the labium by a hinge joint on either side are two leaf-like processes—the labella. It is through the angle made by the two labella that the stylets pass, as a billiard cue between the thumb and index-finger.

The labium proper stops short at the point of junction of the labellum, but is continued on its upper surface as a blunt point covered with fine hairs. It may be likened to a pen, and continued on beyond the penholder, the junction of the pen and penholder being the point at which the labella are hinged on.

The Male.—The labrum and hypopharynx are fused together. The mandibles are absent.

Habits of Mosquitoes.—Water is an absolute essential to the development of mosquitoes, especially stagnant water or the edges of picturesque marshy pools.

A puddle is not essential for the development of the nymph, as a moist piece of ground does equally well; but actual dryness is fatal to mosquitoes in all stages of development.

The staple fare of both sexes is the juices of vegetables; but the female prefers blood when she can get it, and the blood of birds and all sorts of animals is as greedily devoured as that of man.

Mosquitoes can be kept alive in captivity for several weeks on bananas; but the desire for blood is so strong that, it is asserted, they will even bite a corpse.

In cool climates the mosquito becomes lethargic, and either goes back to vegetarian habits or hibernates. Larvæ will remain for two or three months without any development if kept cool.

Mosquitoes in various stages of their development can live for many months, and withstand long periods of cold.

With the exception of the Stegomyia, they are only

energetic at sunset, but in darkened rooms they are common enough in the day; hence our frequent recommendation in previous chapters that all tropical rooms should be brightly lighted.*

The humming and buzzing noises made by mosquitoes varies with the sex and with the species of the insect. It is produced by the vibration of the wings and a special organ. The wings produce the deeper notes, and the special organ the higher ones.

The pain of mosquito-bites is not due to the bite itself, but to the poison which is injected when the insect bites.

It is generally said that this poison is instilled to produce irritation, and thus attract more blood to the part.

This can hardly be the case, as the bite is a distinct disadvantage to the biter.

The true reason is that the poison has the power of keeping the blood liquid, and thus rendering it more suitable to the digestion of the insect.

2. Psychodidæ.

There are two distinct species popularly known as sand-flies.

(1) *The Simulium.*

This is a humped-back little fly which in some parts of America does great damage to live-stock, and even to dogs and cats. The males are harmless, but the female sucks blood.

* An anopheline resting on a wall usually assumes a characteristic attitude. It rests on its first two pairs of legs, and keeps the last pair stretched out. Its body forms an angle with the wall, whereas in most other varieties the body is held parallel to the surface or the tail is tucked in, giving the insect a "hunchbacked" appearance. Too much importance must not be attached to this fact, as a very common malaria carrier—the *M. culicifacies*—looks exactly like a small brown culex as it "sits" with its body parallel to the resting surface.

The larvæ live in quickly running water, and are peculiarly adapted for this mode of life, as they have a sucker at the end of the body which enables them to cling to stones. Moreover, they are able to spin threads which anchor them to suitable projections in the stream.

The fly does not come to the surface to be born from the pupa, but emerges under the water, and floats to the surface protected by a bubble of air entangled amongst the hairs of the legs and body.

(2) *The Phlebotomus.*

The other insect known by the name of "sand-fly" is the owl midge. This variety is like the other in appearance, but is more hairy.

Varieties :

1. *Phlebotomus papatasii.*
2. *P. molestus.*
3. *P. minutus.*
4. *P. babu.*

General Appearance.—Small yellowish-brown flies from $1\frac{1}{3}$ to 2 millimetres in length, with the body and wings densely clothed with long hair. Antennæ, palpi, and legs, long; proboscis straight, projecting vertically beneath the head. Abdomen of the female roseate when full of blood.

Breeding-Places.—Chiefly crannies and crevices in walls.

Eggs.—Deposited in hole bored in detritus of woodlouse and lizard by proboscis of female.

(1) *Colour.*—Opalescent white at first, becoming brown. Surface reticulated.

(2) *Number.*—Thirty to thirty-five.

(3) *Size.*—36 by 12 microns.

Larva.—Thirteen segments. Head distinct. Mouth

parts on central surface. No eyes. Has only prolegs. Body covered with spines. Two tail hairs at first, four later.

Larval Life.—Lasts about sixty days.

Pupa.—Resembles ordinary obtectate pupa. Attaches itself to stone.

Pupal Life.—Twelve days.

Flight.—The flight is strong, forward, and undulating. The last characteristic enables an observer to follow the flight across a well-lit room. Its distance is probably short.

Life-History.—The insect hibernates in the larval stage. The larvæ creep under detritus, and lie almost motionless, feeding for days when the surroundings are favourable ; but excess of moisture causes them to begin to crawl about.

Food-Supply.—Detritus, which appears to consist of woodlouse and lizard excreta, is the chief food-supply. At birth larva will also eat the hairs off the body of the dead fly. They are also cannibals, two or three attacking a weak one, and devouring all but the caudal hairs.

Habits.—The Phlebotomus has a remarkable habit of hopping sideways, and is hard to catch on this account.

They are able to shoulder their way through a mosquito - curtain ; the front pair of legs is first passed through, by which means the meshes are separated and a hole is made big enough to allow the fly to pull itself through.

Food.—The female alone is a blood-sucker. No male has ever been seen biting, nor has one been observed containing blood. Both sexes appear to drink water and to suck moisture.

Sand-flies can be exterminated by measures which deprive them of breeding facilities—viz. :

1. Good walls to houses.

2. Painting or distempering instead of whitewashing walls.

3. Good floors and disuse of matting.

4. Removal of old walls and ruins.

5. Frequent use of formalin spray on walls.

6. Removal of all old woodwork, and painting and varnishing of all doors, etc., yearly.

7. The use of a fine-mesh mosquito-net.

8. Where a net is not available, Marett recommends the following to prevent biting :

Ung. ac. boric. Ung. zinc. ox. Ung. eucalypt.	.. .. āā part. æq.
Calomel	.. gr. v.-x. ad ℥i.

The ointment to be rubbed over exposed parts.

3. **Chironomidæ (Midges).**

Sometimes midges are confused with mosquitoes, but may be distinguished by the short proboscis and the absence of scales on the wings. In the resting attitude they raise the fore-legs and hold them above the head, whereas mosquitoes raise the hind-legs above the rest of their body.

Appearance.—Extremely small flies, not exceeding $1\frac{1}{2}$ to 2 millimetres in length. Males are usually somewhat larger than females, and have tufted antennæ.

Colour.—Blackish or dark grayish-brown. Abdomen of female often rosy, owing to contained blood.

Wings.—Wings closed one over the other like the blades of a pair of scissors when at rest ; often hairy, and frequently speckled with greyish-brown blotches.

Eggs.—The eggs of aquatic species are laid in floating algæ, in star-shaped clusters containing from 100 to 150.

Larvæ.—The larvæ of naked-winged species of

Ceratopogon are aquatic, those of hairy-winged species terrestrial.

1. *Aquatic*.—The larvæ are whitish, worm-like creatures with long, narrow heads. They live in the masses of confervæ floating on the surface of stagnant pools and ditches. They are without prolegs on the prothoracic segment, and progress with a serpentine motion.

2. *Terrestrial*.—The larvæ of the hairy-winged species live under the damp bark of dead trees, in weeping spots on tree-trunks, and in decaying vegetable matter generally, such as manure, rotting fungi, etc. These terrestrial larvæ are usually shorter than the aquatic ones, and do not move in serpentine fashion, but are provided with a cleft proleg on the under-side of the prothoracic segment; while the head and body segments also bear peculiar lancet-shaped hairs and spines.

Nymph.—The nymph, which is shorter than the larva, with a conspicuous pair of respiratory horns on the thorax, is brownish in colour, possesses little power of movement, and remains at the surface of the water.

It has recently been alleged that the midge is the agent for the spread of pellagra.

Group B.

General Characteristics.—This group consists of a large family of insects of the familiar shape of house-flies, and having a proboscis which may be short or long, but is always polished in appearance.

The following species are generally found in houses in the tropics :

1. *Musca domestica* (house-fly).
2. *Homalomyia canicularis* (lesser house-fly).
3. *Calliphora vomitora* (blow-fly).
4. *Lucilia* spp. (bluebottle-fly).
5. *Sarcophaga* spp. (flesh-fly).

The *Musca domestica* is a medium-sized greyish fly, with its mouth parts spread out at the tip for sucking up liquids. It breeds in a great variety of substances of a filthy nature, and is found in practically all parts of the world. On account of the conformation of its mouth parts, the house-fly cannot bite.

Several kinds of metallic green or bluish colour flies are occasionally found in houses, the most abundant of which is the so-called "bluebottle-fly." This insect is also called the "blowfly" or "meat fly," and breeds in decaying *animal* material.

It feeds on the fæces of man to a great extent, and is very partial to fruits of various kinds; hence it is very likely to be a carrier of disease.

In most parts of the world the house-fly prefers to lay its eggs upon horse-manure, this substance being its favourite larval food; but it is not always available for it in the tropics, where in many parts every scrap of manure is made into cakes and used as fuel. In the tropics the fly develops a taste for human excrement, and from this habit it becomes very dangerous to the health of human beings, carrying as it does the germs of intestinal diseases, such as enteric fever and cholera, from excreta to food-supplies. It will also lay its eggs on any decaying vegetable and animal material, but of the flies that infect tropical houses a vast proportion comes from either human excrement or horse-manure. As the fæces dry and crumble, the maggots bury themselves in the earth, finding a passage by way of cracks and the holes made by worms or dung-beetles.

The excrement of dogs has also been found to serve as a breeding-place for various flies which haunt houses and hospital wards. Cow-dung and the earth under it harbour fly maggots, but experiments have shown that house-flies do not breed in ordinary ground as distinguished from organic deposits.

To attract the house-fly, ordinary household refuse must be in a state of fermentation, as flies breed in relatively small numbers in refuse where fermentation has not taken place. They do not breed at all in receptacles which are emptied at short intervals, but the use of disinfectants, as ordinarily carried out, does not prevent them breeding in such receptacles unless they are regularly emptied. Very dry or excessively wet ashes or moist cow-dung does not harbour them.

The presence of fowls, but not ducks or geese, reduces the number of larvæ and pupæ in stable litter to a very marked extent, and there are certain species of ants which destroy them with great rapidity.

The duration of the egg state of the house-fly is twenty-four hours, the larval state from three to five days, and the pupal state from five to seven days.

The periods of development vary largely with the climate and season. The insect hibernates in the pupal form in manure, or at the surface of the ground under a manure-heap. In the adult form it also hibernates in dark nooks and crannies in houses. The unceilinged roofs of tropical bungalows and native houses offer limitless facilities for flies to enjoy undisturbed winter repose.

The number of eggs laid by an individual fly averages about 120, and the enormous numbers in which the insect occurs is thus plainly accounted for, especially when we consider the universal presence of appropriate food.

Indeed, their fecundity, the rapidity with which one generation succeeds another, and their great voracity, added to the extraordinary quickness of their production, are such that Linnæus tells us that three flies, with the generations which spring from them, could eat up a dead horse as quickly as a lion could.

Paris green, in the proportion of an ounce to the

gallon of water, added to either stable manure or fermenting household refuse, destroys 99 per cent. of the larvæ.

The presence of flies in a house means that filth is near at hand.

Austin's table shows clearly the characters of the two chief varieties of house-flies, and also that of *Stomoxys calcitrans*.

Preventive Measures against Flies.

1. *Natural Enemies.*

1. The centipede.
2. Certain beetles.
3. Certain varieties of ants.
4. Spiders.

2. *General Preventives.*

1. Careful screening of all windows and doors during the summer months.
2. Sticky fly-papers.
3. The prompt gathering of horse-manure, which may be variously treated or kept in specially-prepared receptacles.
4. The use of disinfectants in latrines.
5. Absolute domestic cleanliness.

The following rules for dealing with the fly nuisance may be useful for health officers' circulars.

1. Keep all flies away from the sick, especially those ill with contagious diseases. Kill every fly that strays into the sick-room. Its body may be covered with disease germs.
2. Do not allow decomposing material of any sort to accumulate on or near your premises.
3. All refuse which tends in any way to fermentation, such as bedding, straw, paper waste, and vegetable matter, should be disposed of, or covered with lime or kerosene-oil.

4. Screen all food.

5. Keep all receptacles for garbage carefully covered, and the cans cleaned or sprinkled with oil or lime.

6. Keep all stable manure in vaults or pits screened or sprinkled with lime or kerosene emulsion.

7. Cover food after a meal, and burn all table refuse.

8. Screen all food exposed for sale.

9. Screen all windows and doors, especially the kitchen and dining-room.

10. Don't forget, if you see flies, their breeding-ground is near at hand.

If there is no filth, there will be no flies.

Group C.

This group includes (1) Tabanidæ ; (2) Glossina.

Tabanidæ. — Majority of blood - sucking Diptera belong to this family.

Appearance.—Generally rather large, flat-bodied flies, with broad head and eyes coloured with green or purple bands or spots. Antennæ point straight ahead, rather variable in shape. Coloration sombre. Wings tectiform, banded, and notched.

Breed mostly in mud at edges of streams and ponds. Development requires about two months, often longer.

Glossinæ—*Appearance.*—Brownish colour, 7 to 12 millimetres long. Wings close like scissors ; venation characteristic.

Hard chitinous proboscis ensheathed in palpi ; has onion-shaped bulb.

Arista is a fine bristle-shaped process feathered on upper side only.

The female produces a single yellowish larva at a time, which is retained and nourished within the ovi-

duct of the mother until full-grown, and on being extruded at once crawls away, and turns into a pupa as soon as it finds a suitable hiding-place. The pupa is dark brown, with a pair of prominent granular protuberances at the posterior extremity.

Glossina palpalis is the chief carrier of the Trypanosoma of sleeping sickness.

Gambiense the cause.

THE HEMIPTERA.

The only family of hygienic interest is the Cimicidæ, or bed-bugs.

Two varieties attack man—viz. :

1. *Cimex lectularius.*
2. *C. rotundatus.*

Appearance.—The body is soft, oval, about $\frac{1}{5}$ inch in length, of a reddish-brown colour, and covered with a little hair.

Eggs.—The eggs are laid in cracks in the floor, or in the furniture, or in a convenient position to which the female can gain access. They are beautifully shaped and sculptured, and the young escape by a round door at one end about five to ten days after they are laid.

Nymph.—The young are similar to the adult, but smaller, more transparent, and less darkly coloured. There are probably five moults, and if the insect is under favourable conditions, where it can get blood easily, the whole life-history will probably not occupy more than two months. A meal of blood seems to be required before each moult and before egg-laying, and if it cannot be obtained the interval between moults may be very greatly prolonged.

Habits.—The adult insect feeds about once in from thirty-six to forty-eight hours, taking nearly fifteen

minutes to get its fill of blood. At earlier ages the feeding period is much shorter.

It is nocturnal as a rule, but active at all times.

It abounds in dirty houses, principally in towns of warm climates. It lives in beds, woodwork, behind pictures, under matting and carpets.

Distribution.—Almost world-wide, as it is readily carried in steamers, and can survive for long periods, even as long as a year, without food. This accomplishment enables it to live from season to season in hill bungalows, empty hotel apartments, and the like.

Transmits kala-azar, according to Patton,* and probably cerebro-spinal meningitis and typhus fever.

Preventive Measures.—1. Fumigation with formaldehyde or sulphur.

2. Cleanliness.

3. Washing the floor and wooden bedsteads with kerosene-oil emulsion.

4. The use of pure pyrethrum powder.

5. The leaves of the *Pterospermum acerifolium* are used in India as a preventive against night attacks.

Natural Enemies.—Cockroaches and small red ants.

THE ANOPTERA.

This order includes the Pediculidæ, or lice family, which are closely allied to the bug tribe. Three species infect man in the tropics—viz. : (1) *Pediculus capitis*, the head louse ; (2) *P. vestimenti*, the body louse ; (3) *Phthirius inguinaris*, the crab louse).

1. Pediculus Capitis.

Appearance.—Of greyish colour, with a flat, slightly transparent body. It is spotted with black on the spiracles, soft in the middle, and rather hard at the sides. The head is oval, and furnished with two

* "Scientific Memoirs," Government of India, No. 50.

thread-like antennæ, composed of five joints, which are constantly in motion whilst the creature is walking. Its eyes are black, round, and of simple structure. In the front of the head is a short, conical, fleshy nipple. This nipple contains the sucker, or rostrum, which, when extended, represents a tubular body, terminating in six little pointed hooks, bent back, and serving to retain the instrument in the skin. The organ is surmounted with four fine hairs fixed to one another. It is by means of this complicated apparatus that the louse pricks the skin of the head. The limbs are thick, terminating in a strong claw, which folds back on an indented projection, forming a sort of pincer. It is with this pincer that the louse fastens itself to the hair.

Eggs.—White and barrel-shaped. Deposited on the hair, and are commonly called "nits."

No metamorphosis occurs ; the young are hatched in the course of five or six days, and in eighteen days develop full sexual powers. It has been calculated that in two months two female lice produce 10,000. Naturalists have asserted that a second generation of a single individual can amount to 2,500, and the third to 125,000.

2. Pediculus Vestimenti.

The body louse is larger than the head louse.

3. Phthirius Inguinaris.

The crab louse is found on the pudenda. It is very readily communicated from man to man.

It has recently been shown by Rogers that the parasite of relapsing fever is conveyed by pediculi.

Destruction of Lice.

For the head louse, when the condition is very bad, the hair should be cut short, as it is difficult to destroy

thoroughly all the nits. Repeated saturation of the hair with turpentine or with lotions of carbolic acid (1 in 60) are usually efficacious. Scrupulous cleanliness are sufficient to prevent recurrence. In the case of the body louse, the clothing should be disinfected by steam. To allay itching, a warm bath containing 4 to 5 ounces of bicarbonate of soda is useful. The skin may be rubbed with a lotion of carbolic acid containing 2 drachms of pure carbolic acid and 2 ounces of glycerine to the pint of water. For the crab louse the parts should be thoroughly washed two or three times a day with soft soap and water, and unguentum hydrargyri ammoniata or unguentum hydrargyri applied.

THE SIPHONAPTERA.

Two chief classes:

1. Pulicinæ.
2. Sarcopsyllinæ.

Fleas were originally flies and had wings, but their form and structure has in the course of ages become profoundly altered in consequence of their parasitic habits.

1. Pulicinæ.

General Characters.—Small head, well-marked eyes, eggs not fixed to hairs.

Chief Members :

1. *Pulex Irritans* (*Human Flea*).—Large size, brightly coloured, eyes distinct. Found in dark and dirty habitations, usually on man only. No bristles behind head, but bristles on posterior extremity of abdomen. Claws large and scythe-like.

2. *Pulex Cheopis* (*or Pallidus*).—Resembles *P. irritans* but is smaller in size and more brightly coloured.

Loves the dark, and is very sensitive to light. Claws small and sickle-shaped. Rat flea of the tropics.

3. *Pulex Serraticeps* (*or Felis*).—A small flea of dark colour. *Not* nocturnal in habits. Lives on dog, cat, rat, man, and monkeys. Has combs behind head, and teeth-like bristles around mouth.

4. *Pulex Fasciatus* (*or Ceratophyllus fasciatus*).—Found on common European rat. Has combs behind head, but no bristles around mouth.

Pulex Irritans.

Body is oval, somewhat flattened, and covered with a hard horny skin of brilliant chestnut-brown colour. Head is small in proportion to its body. There are two small jointed antennæ of cylindrical form. The eyes are simple, large, and round. The rostrum is composed of an exterior jointed sheath, having inside it a tube, and carrying underneath two long, sharp lances with saw-like edges.

The quantity of blood absorbed is enormous compared with the size of the insect.

The limbs are long and strong. The foot has five joints, and terminates in hooks turned in opposite directions. The two anterior limbs are separated from the others, and are inserted nearly underneath the head ; the posterior ones are particularly large and strong. The jumps of the flea are gigantic, and its strength quite herculean, when compared with the size of its body.

Eggs.—The eggs, about twelve in number, are oval, smooth, and white. They are laid on the ground, between the boards of floors, in old furniture, and amongst dirty linen and rubbish. Mixed with the eggs is always found some dried blood, provided by the mother for nourishing her young.

Larva.—Larva hatches out in fifty hours to five days in tropical climates. They are of cylindrical

form, covered with hair, and divided into three parts, the last being provided with two small hooks. The head is scaly above, has two small antennæ, and is without eyes. These larvæ have no legs. Though at first white, they soon become a reddish colour.

After about a fortnight they spin a cocoon, inside which they are transformed into pupæ, and in another fortnight these pupæ become perfect insects.

The insect is most abundant in dirty houses, deserted buildings, ruins, and in places frequented by people of uncleanly habits.

Pulex Cheopis.

The rat flea is essentially a parasite of the rat, but it does not confine its attacks to these animals, and it will bite man, especially (but not only) when there are no rats on which it can feed. It is well known that, before plague attacks men of a village, the rats of the place usually die of the disease. When the rats die, the rat fleas leave their bodies, and then are particularly liable to bite men, and thus infect them with the plague bacillus which the fleas have previously sucked up with the blood of the rats on which they last fed.

Iodoform is said to be a most efficient means of banishing fleas ; a trace of this drug on clothes is sufficient to keep all fleas at a distance. It should therefore be a valuable prophylactic in plague-infected districts.

2. **Sarcopsyllinæ.**

General Characteristics.—Head large and forehead angular ; thorax narrow.

Three varieties :

1. *Sarcopsylla* (*Pulex Penetrans, or Chigger Flea*).
2. *Rhynocopsylla.*—Found on parrots and other birds.

3. *Vermipsylla.*—Found on horses and cattle.

The only member of this variety of interest is the *Pulex penetrans*, the chigger or sand-flea.

This insect is not unlike the common flea, but is smaller in size. It is flat, brown in colour, with a white spot on the back, and is armed with a powerful rostrum composed of a long epipharynx prolonged from the pharynx. It is hollow, but there is no opening at its extremity. The under-surface is grooved, and continuous with the wall of the pharynx. The mandibles are grooved on the mesial surface. In the act of biting, the epipharynx and mandibles are driven into the skin, and the approximated mandibles form a passage down which the salivary secretion is forced ; and blood is sucked up, *not* along the same channel, but along an upper channel formed by the approximation of the epipharynx and the two mandibles.

The maxillæ are not utilized in biting, and the labium merely acts as a sheath, and is doubled back in the act as in the mosquito.

Its favourite haunts are dry, sandy soil, the dust and ashes in badly-kept native huts, the stables of cattle, poultry-pens, and the like. It greedily attacks all warm-blooded animals, including birds and man.

The female, when impregnated, settles on the skin, and burrows in a slanting direction. It slips in between the flesh and the nails or gets under the skin of the heel. The process does not cause any pain at first, but after a few days irritation appears, which, although at first slight, gradually increases, and ends by becoming unbearable.

The chigger, when under the skin, proceeds to ovulation, and in consequence becomes as large as a small pea. The skin over the surface may ulcerate and the chigger be expelled. This sometimes occurs before the eggs are laid, but more frequently after-

wards. If the insect is not extruded before the time of laying eggs, these are expelled either through the small opening in the skin made by the insect when she entered, or through the larger ulcerated opening, caused by the inflammation. In either case the eggs fall to the ground, and after a few days a thirteen-ringed larva is hatched out. This larva soon encloses itself in a cocoon, and undergoes further development, and in from eight to ten days' time the imago emerges.

As the cause of suffering and disability, the chigger is an insect of some importance. It is now extremely prevalent on the East Coast of Africa, and causes a large amount of invaliding amongst Indian coolies.

THE HYMENOPTERA.

This order embraces some of the most interesting of insects, including bees and wasps ; but the only members with which we are interested in relation to the transmission of disease are the *Formicidæ*, or ants.

These insects are, in general, small creatures of a brown or black colour.

Like bees, they are social insects. They live in communities in which there is a considerable amount of specialization of forms to serve the purpose of a useful division of labour. Their little republics consist of males and females and various forms of workers, but the degree to which this specialization goes varies very much with the species. Commonly there are two or three forms of workers—the soldier, with large head and mandibles ; and the workers, major or minor, with more normal structure. A nest may consist of a greater or smaller aggregation of individuals, and there are a few species which share the light-shunning habits of the white ants ; but most varieties nest in soil, trees, etc., and work in the light.

In general the ants are scavengers, the workers

bringing to the nest the food for the whole community. This food consists of dead insects and other animal matter, the sap of plants, and any edible vegetable matter that can be obtained. In this sense ants are excellent scavengers, and, as they are practically everywhere in the open, they serve an extremely useful function in the tropics.

Life-History.—The life-history of ants is very similar to that of bees.

The eggs are laid by the female, and tended by the workers in the nest. The larva hatches out in about a fortnight, and is a white helpless grub, without legs and incapable of exertion, which is fed by the workers. In some varieties the pupæ are free, in others in silken cocoons which the larva itself prepares. The larvæ and pupæ live in specially built galleries in the ant-hills.

Hitherto no conclusive evidence has been adduced against the ant as a disseminator of disease; on the contrary, a certain species is said to render valuable service by destroying the eggs and larvæ of house-flies.*

THE ARACHNIDÆ (SPIDER FAMILY).

The members of this group we have to consider are not numerous. As already pointed out, they are not insects, but allied to spiders and scorpions. The members known to affect man are—

1. Sarcoptes Scabei.

This member of the tribe produces scabies. The male is rarely found, but the female can readily be seen with the naked eye. It has a pearly white colour. It makes for itself a small burrow in the skin forming the web of the fingers and toes, the backs of the hands, and the armpits.

* Captain Jones, *The Military Surgeon*, July, 1910.

The lesions which result from the presence of this parasite are very numerous, and result largely from the scratching which it induces.

Like the *Demodex folliculorum*, it has been accused of acting as an agent for the dissemination of leprosy, so that its early destruction is especially desirable in the tropics.

2. Demodex Folliculorum.

This arachnid lives in the sweat-glands at the roots of hairs, and in diseased follicles in the skin of man and some domesticated animals. The diseased follicles become filled with fatty matter; the upper end becomes hard and black, and in man are known as "blackheads." If one of these blackheads is forced out and the fatty substance dissolved with ether, the mites may be found in all stages of development. The young have six legs, the adult eight. The body is elongated and transversely wrinkled.

Recently it has been observed that the *Bacillus lepræ* is often closely associated with these face mites, and it has been asserted that they are concerned in the spread of leprosy.

3. The Ixodidæ (Ticks).

These little animals constitute a large section of the Arachnidæ, and play an important part in the transmission of disease. They are widely distributed, many animals having special species of their own.

They are always visible to the naked eye.

The subfamilies are—

1. Ixodinæ.
2. Argasinæ.

Distinguishing Features.—The Ixodinæ only moult twice during their life—viz., at the change from larva to nymph, and again from nymph to adult; the

Argasinæ moult not only at these periods, but also several times during the adult stage. The Argasinæ also do not become distended with blood to the enormous extent so characteristic of the Ixodinæ.

Appearance.—Vary greatly in size. Usually yellow in colour when young, deepening to dark brown in the adult stage.

The head, thorax, and abdomen, are fused together. The Ixodinæ have a dense chitinous plate called the "scutum," covering in the male the whole, and in the female portion, of the dorsum. This is absent in the Argasinæ. Eyes are present in some varieties, absent in others.

The organs chiefly concerned in biting are the hypostome—a conspicuous dagger-shaped process, with a number of teeth directed backwards and arranged in rows—and the mandibles, or cheliceres, which are very powerful, and carry a jointed process, the digit, which bears large hooked teeth.

The females are almost invariably larger than the males, and in some species, when gorged with blood, may reach a length of nearly ½ inch. As a rule they are temporary parasites, but some live in a quasi-permanent manner on the body of their host, and a few burrow beneath the skin.

After fertilization the male dies, but the female attaches herself to her host, and proceeds to gorge herself with blood for the development of her ova. Becoming enormously distended with blood, she drops off and secretes herself in some nook or cranny, where she deposits her eggs, which are small, yellowish, roe-like grains.

Each female lays several thousands of eggs, and occupies some weeks in the task. After a period varying from a few weeks to several months, the eggs are hatched out on the ground. The larvæ look like grains of sand. These minute creatures crawl to

a summit of a blade of grass, and there await for weeks or months the passage of some animal, to which they can cling.

They live on the animal for a few days, and then fall off, developing on the ground, first into the nymph, and later (with or without the intervention of a second host) into full-grown individuals of both sexes, which get on the body of an animal and mate. The female then falls off and lays eggs, which in due course develop into larvæ and start the cycle anew.

The tick may convey disease in any of its stages of development, and some varieties lay eggs which produce larvæ which are infective.

The duration of life is probably a year or more, but, on account of the difficulty of finding an appropriate host, ticks are endowed with a phenomenal capacity for fasting, and they have actually been found alive after a fast of four years' duration.

The tick lives in native huts. It is nocturnal in its habits, hiding during the day in cracks in the walls and floors, or in the thatched roofs. It feeds slowly, and is unable to get much blood from any but sleeping persons.

"Ulcers" and a severe form of fever which is common in Southern India are popularly attributed to *O. savignyi*.

An African tick, *Ornithodorus moubata*, has been proved to be the disseminator of the "coast" or "tick" fever, which closely resembles relapsing fever.

The propagation of disease by body insects is of the greatest interest to the epidemiologist, as it serves to explain obscure epidemics of relapsing and other fevers, which have frequently been carried from point to point in a hitherto quite inexplicable way.

CHAPTER X

ANIMAL PARASITES

In the whole range of his duties, there is no subject of deeper interest to the health officer in the tropics than the relation of animal parasites to disease.

The members of the following zoological orders supply the parasites of man :

1. Protozoa.
2. Cestoda.
3. Trematoda.
4. Nematoda.

Only the two former will be considered in this volume, as the Trematoda and Nematoda of tropical interest are admirably dealt with in the companion volume of "Aids to Tropical Medicine."

1. Protozoa.

The Protozoon individual is a single corpuscle of protoplasm, varying in size when adult from less than one-thousandth part of an inch in diameter (some Sporozoa and Flagellata) up to the diameter of an inch (Nummulites), and even a much larger size in the plasmodia of Mycetozoa.

Growth and reproduction by fission may continue for many generations, but sooner or later their true animal character is demonstrated by the introduction of a process of sexual union.

The sexual process may intervene at any period of the life-cycle, and may either precede or follow rapid

reproduction by fission, and conjugation, though generally associated with reproduction, may occur independently of it. True conjugation in Protozoa consists of the fusion of the nuclear substance from two individuals.

The individuals going through this process are called *gametes*, and if the union extends to the fusion of the whole bodies of the organism, the resulting individual is called a *zygote*.

The gametes may be similar in all respects, or may be differentiated into *microgametes*, regarded as males, which are smaller and more motile, and *macrogametes*, regarded as females, which are more bulky, often full of reserve material, and less, or not at all, motile.

The following three classes, arranged in the ascending scale of animal development, have to be considered :

1. Sarcodinia, or Rhizopodia, composing those forms having the general characteristics of Amœbæ.

2. Mastigophora, or Flagellata—*i.e.*, forms having flagella.

3. Sporozoa—viz., those forms of Protozoa which are rarely amœboid, and multiply by a form of sporulation.

1. **Sarcodinia.**—True Amœbæ are divided into two groups : (*a*) Thecamœbæ, or those provided with a hard envelope of shell ; and (*b*) Gymnamœbæ, or those consisting merely of homogeneous protoplasm. The members of the first group are not concerned in disease, but two individuals of the second group are of great interest.

One of these, the *Amœba coli*, renamed by Schaudinn the *Entamœba coli*, is a harmless parasite, whereas the second, which he styles the *E. histolytica*, is a most lethal organism.

The Entamœba has two well-marked methods of

reproduction—one merely vegetative, and the other clearly sexual in type.

The asexual form consists in simple segmentation of the nucleus into eight parts, which surround themselves with protoplasm, and separate into a brood of young Amœbæ.

In the sexual cycle of reproduction the organism comes to rest, contracts, and surrounds itself with a gelatinous coat, which becomes the cyst wall.

The nuclei, after undergoing reconstruction, divide, copulate, and then divide again ; so that the parent nuclei eventually form eight young Amœbæ, which are enclosed within the cyst wall, and, like the cysticercus of the tapeworm, cannot start in life on their own account until the cyst has been taken into the stomach of a new host, and the gelatinous cyst wall dissolved by the intestinal juices.

The *E. histolytica*, as the *A. dysenteriæ* is called by Schaudinn, differs widely in appearance and mode of production from the non-pathogenic type of organism.

It has a clear, tough ectoplasm and an ill-defined nucleus, and this tough outer layer enables the parasite to force its way between the epithelial cells of the intestinal mucous membrane into the deeper layers and submucosa, where it undergoes development, destroys the tissue, and thus forms the ulcers characteristic of dysentery.

E. histolytica in its asexual form multiplies by simple fission, or forms new Amœbæ by budding. "The characteristic brood formation" of the non-pathogenic organism does not occur.

The cystic stage is also produced in a different way, and it is of special interest to note that it is not formed till the patient is beginning to recover from his attack, and the stools are becoming solid, a fact which is of the greatest importance in framing preventive measures against the disease.

The Protozoon throws out from its surface a series of little knobs, about 3 microns in diameter, each containing a particle of chromatin. These knobs break off, and, having developed a firm capsule, ultimately become hard, opaque little bodies called "spores."

These bodies are expelled in the fæces, and on being taken into the intestinal tract infect a new host.

They are most readily found in the smaller pieces of mucus. The organisms disintegrate with heat, so the films cannot be fixed in the Bunsen flame. They should be dried in air, and then placed for five minutes in Gulland's fixing solution, which is made up as follows:

Absolute alcohol	25 c.c.
Pure ether	25 ,,
Solution of corrosive sublimate in alcohol (strength, 2 grammes in 10 c.c.) ..	5 ,,

The films should then be immersed in carbol fuchsin for three minutes, washed vigorously for thirty seconds, and dried in air.

2. **Flagellata.**—The next class of Protozoa on the upward scale is the Mastigophora, containing the subclass Flagellata, which includes the great family of Trypanosomata.

The Trypanosome of all varieties is a somewhat fish-like structure, with a fin-like projection called a "flagellum." In the body are two basic staining granules and two chromatin masses, one in the middle, called the "macronucleus," and the other in the tail, or posterior, called the "micronucleus."

The pathogenic properties of the organisms depend on their power of adapting themselves to various hosts when transferred to individuals of a new species. from animals in which they naturally occur, by a variety of biting flies.

The features of development common to all forms of Trypanosomata are somewhat as follows :

The individual organisms are differentiated into male, female, and indifferent forms. All three varieties may multiply by splitting longitudinally, a process which takes place in the following way : (1) The macronucleus becomes dumb-bell-shaped, and splits in two ; (2) the micronucleus behaves in a similar way ; (3) a second flagellum is produced ; (4) fission begins at the tail end ; but (5) actual separation commences at the head, and goes on till two fully-formed Trypanosomes are produced.

This process may fall into abeyance when sexual forms become fully developed. The three types may be observed in the vertebrate host, but are usually not clearly differentiated except in the invertebrate host.

The males are much more slender than the females, and are so delicate in constitution that they soon die off if they do not conjugate.

The indifferent types are hardier than the males ; but the females are the most resistant of the three, as they have a quantity of reserve material stored up in their interior.

The male and female forms undergo a process of maturation in the gut of the biting fly, which acts as intermediate host, and it is in this position that the act of union can alone take place.

The sexual forms undergo complete fusion in the process of conjugation, and the resulting zygote is an individual similar to the oökinet, or vermicule, stage of the malarial parasite. This stage, however, gradually develops an undulating membrane and flagellum, and becomes an ordinary Trypanosome, which takes on a vegetative cycle of existence.

Under adverse circumstances the female Trypanosome can undergo a species of self-fertilization, and

repopulate its vertebrate host, its descendants being gradually differentiated into male and female.

Such, very briefly, is the ordinary life-cycle, but of course many modifications exist, and certain phases and forms of Trypanosomata cannot be attributed to these comparatively simple data.

Closely allied to the Trypansomata is the group of organisms known as "Spirochætæ," which were long confused with the class of bacteria called Spirilla, and in close kinship with the Spirochætæ is the genus of Flagellata, known as Herpetomonas. This sub-order is of special interest, as it contains—

The Leishman-Donovan Bodies.

These peculiar bodies were discovered in 1900 by Leishman, and independently in 1903 by Donovan. They are invariably found in the spleen pulp and bone marrow of patients suffering from kala-azar.

The Leishman bodies are ovoid or pear-shaped, about 3 microns in the longest and 2 microns in the shortest diameter. They contain two nuclei or chromatin masses, situated in the short axis of the body.

One of the masses is much larger than the other, more or less spherical in shape, and stains faintly, whereas the other is generally rod-shaped and stains very deeply. Sometimes a bridge of protoplasm unites the two nuclei. The parasites multiply by binary or multiple fission.

They can be grown in citrated blood into distinct flagellated organisms.

No conjugation occurs, however, in laboratory-grown organisms, which simply degenerate and die off without further development.

The bed-bug is probably the invertebrate host for the transmission of these organisms.

3. **Sporozoa.**—The Sporozoa are so called because at some time in their life-history the individual

Sporozoon breaks up into a number of small bodies resembling spores.

The genus to which the malarial parasites belong is called the Hæmamœba, because they live in, and at the expense of, the blood-corpuscles.

There are many varieties of organisms found in the blood of various animals.

The varieties found in man are—(1) The *Plasmodium malariæ*, producing quartan ague; (2) the *P. vivax*, producing benign tertian; and (3) the *Laverania malariæ*, Grassi, the cause of malignant tertian ague. All three have a double cycle of development—one sexual, and the other asexual.

The asexual cycle can take place entirely in the blood of man, but the sexual requires a change of *host-species* as distinguished from *host-individual*, and cannot occur without the intervention of the mosquito.

The process of development starts from the small spore-like bodies from which the sporozoa class derives its name, finding their way into the blood, fixing themselves on to the red corpuscles, and boring their way to the interior of these cells.

In the second stage of development we have, therefore, the plasmodium inside the red blood-corpuscles forming the ring shape, with the chromatin at one spot.

From the ring shape the parasite may take on the sexual or asexual form.

Asexual Cycle.

The parasite grows at the expense of the corpuscle, absorbs its fluids, and rapidly increases in size. It abstracts the hæmoglobin from the stroma of the cell, and alters it into a black or brown pigment, called "hæmozoin" or "melanin."

In the interior of the corpuscle the parasite is motile, and throws out processes which alter in shape;

but when it comes to occupy the greater part of its host cell, the chromatin of which it is largely constituted begins to split up into two, four, eight, twelve, or more segments.

On the completion of this process of segmentation, the Protozoon has divided into several fragments of chromatin, each surrounded with protoplasm, and arranged in the form of a daisy or rosette, with melanin granules in the centre, forming the stamens of the daisy or centre of the rosette.

The petals of the daisy or loops of the rosette constitute the small bodies originally referred to as "spores"; and when this curious malarial blossom is full-blown, the remains of the red-cell rupture and its baleful contents are set free to attack fresh red blood-corpuscles and start the cycle anew.

The hæmozoin or melanin passes into the blood-stream, and is carried by the leucocytes to the tissues, producing the darkening of the skin and organs which is so familiar in subjects of malaria.

The process detailed constitutes an asexual developmental cycle of the parasite, and in quotidian ague takes only twenty-four hours from spore to spore.

If quinine is not given, this goes on until, owing to the production of specific anti-bodies, or the exhaustion of the reproductive power of the parasite under the strain of a repeated asexual division, this process gradually ceases, and specially differentiated males and female forms appear in the following ways:

Starting from the ring shape, the sexual cycle proceeds at first in much the same way as the asexual, hæmozoin and chromatin being formed; but when the parasite is one-third formed, it can be seen in a clear unstained zone, called the "vacuole," which is characteristic of this form of development. Another special point in this form of development is that the chromatin mass shows no tendency to segment.

When the Protozoon nearly fills the red cell it is called a "gamete" or "gametocyte"; and if the patient is not bitten by a mosquito at this particular period the parasite dies, but if the organism passes into the stomach of a mosquito its true sexual life begins.

The male gametes are called, as we have seen, "microgametocytes," and the female "macrogametocytes."

Ten minutes to half an hour after the blood has been sucked in by the mosquito, the microgametocyte, which is readily recognized by its hyaline plasma, large nucleus, and coarsely granular pigment, exflagellates four to eight filaments, about 20 microns long and 1 micron thick.

These flagella are actively motile, and are soon set free, being given the name of "microgamete" when in the free state. Meanwhile the macrogamete has been preparing itself for fertilization by ejecting part of its nucleus, and the extruded matter may act chemiotactically in attracting the microgametes.

On the approach of the male, the macrogamete protrudes a "receptive eminence," or microphyle, and as soon as a male adheres to this the eminence is at once withdrawn, dragging the struggling microgamete into the body of the female. This completes the act of copulation, and the macrogamete now secretes a coat of mucus, which keeps away all other males, and is styled a "zygote" or "fertilized macrogamete."

The zygote rapidly changes into an oökinet, or motile body, which reaches the wall of the mosquito's stomach, worms its way through the epithelium, and comes to rest between the layers of the muscular wall of the stomach.

In this situation it is called an "oöcyst," and, having originally only been 7·5 microns—*i.e.*, the diameter of a red blood-corpuscle—it hextuples its

size, and becomes 50 microns, so that it can be seen with an ordinary lens.

A tough resistant membrane develops round the oöcyst, which soon begins to segment into a mulberry-shaped mass. This mass finally splits up into a number of secondary cysts, or sporoblasts, which are full of elongated thread-like bodies, each containing chromatin, called "sporozoites." The sporoblasts eventually burst, and the sporozoites are accordingly set free in the general blood-stream of the mosquito. They are carried everywhere, including the neighbourhood of the salivary glands, from whence they enter the salivary cells and ducts; so that when a mosquito bites an animal he injects several of these fully developed sporozoites, which proceed to attack the red blood-corpuscles and start the malarial cycle.

Some of the sporozoites are said to enter the ovary of the young of the mosquito, and there infect the ova; so that the young brood of next spring harbour the parasites, and the young mosquitoes can confer malaria without having sucked the blood of an infected individual, a condition of things which, if confirmed, will explain many epidemiological problems which have puzzled medical officers of health in every part of the tropics.

The table on pp. 150 and 151 gives the special characteristics of each parasite.

The points in structure common to all three may be summarized as follows:

1. All live in and at the expense of the red cells. 2. All are amœboid—*i.e.*, are endowed with movement, said to be due to (*a*) hæmozoin moving round, and (*b*) pseudopodia being formed. 3. All manufacture melanin. 4. Nearly all produce various degenerate changes in the red blood-corpuscles. 5. In the fresh state all are colourless, but when dead the protoplasm stains blue, and the chromatin red, by

Romanowsky's method of staining. 6. Each variety has a definite period of growth—seventy-two hours in quartan, forty-eight hours in tertian, etc. 7. All possess sexual and asexual forms—*i.e.*, are capable of forming gametes.

The Piroplasmata.

This is a group of protozoal parasites belonging to the genus Hæmocytozoa, which are conveyed by ticks, and produce a condition found in man, rats, oxen, horses, and dogs, called "piroplasmosis." The parasites are pear-shaped bodies which are found in the red cells, and they produce in infected animals all the symptoms of progressive hæmolysis—viz., pyrexia, asthenia, anæmia, jaundice, etc., ending in death.

They do not produce pigment, and they multiply in the blood by fission.

The blood of an infected animal does not give rise to piroplasmosis when directly transferred under the skin of a healthy one. It is only after it has passed through the body of a tick that the piroplasma can give rise to disease.

2. Cestoda.

The Cestoda are extremely common in the tropics. From consideration of space, the characteristics of the varieties of interest to the tropical hygienist are given in the table on p. 152.

CHARACTERISTICS OF THE THREI

Name of Parasite and Type of Fever it produces.	*Effect on the Red Blood-Corpuscles.*	*Character of Melanin produced.*	*Number of Segments in "Daisy" Rosette.*
Plasmodium vivax; produces benign tertian fever	The corpuscles are enlarged to two or three times their normal size, and paler	Coarse, light brown granules	15 to 25
Plasmodium malariæ; produces quartan fever	The corpuscles are diminished in size, and do not become paler. The parasite fills the whole cell	The granules are coarser and darker in colour. It is in this variety you get the true daisy shape	8 to 12. Number of rosettes in peripheral blood is greater than in *B. tertian*
Laverania malariæ, Grassi produces malignant tertian or æstivo-autumnal fever	The corpuscles are not enlarged. They do not become paler, but, on the contrary, some grow darker. The parasite does not fill the cells, which frequently become shrunk and crenated	"The melanin is arranged as in quartan parasite" (Leishman)	There is much difference of opinion, and Leishman teaches that it is best to say "uncertain"

NOTE 1.—Malignant tertian malaria has been called (1) "pernicioı malaria," (2) "æstivo - autumnal fever," (3) "tropical malaria," (4) "re mittent malaria," (5) "subtertian fever" (Manson). It may be define as a form of malaria in which alone the gametes have a crescent form, an might well be called "crescent tertian fever"—a synonym now recognize in the official nomenclature of diseases. Chromatin is difficult to stain, bu exflagellation is easily demonstrated in crescents

MALARIAL PARASITES AFFECTING MAN.

Degenerative or Other Special Changes produced in Red Cell.	*Special Characters of Ring Shape.*	*Effect of Quinine.*	*Effect of Parasite on the Spleen.*
A number of red staining spots, called "Schuffner's dots," can be demonstrated with Leishman's stain. They increase only in size, and not in number	Ring larger than in malignant tertian	Quinine destroys the parasite and cures the fever	Enlargement is common, but not invariable
No degenerative changes can be seen, and if your technique is correct this enables you to settle type of fever	Ditto	Ditto	Ditto. This was the variety of fever at one time common in England, which produced the "ague cake" of the Fens
Following out rings which are going to become rosettes, Maurer found certain markings which appear to be marks of sears made in stroma of cell by parasite. Increase in number, but not in size	Rings are smaller and more delicate in shape than in other varieties. Present in peripheral blood in larger numbers than in other varieties, and if many rings are observed in blood-film suspect malignant tertian	Very resistant to quinine	Splenic enlargement is rare

NOTE 2.—The names applied by different authors to the malarial parasites are confusing. The terminology followed above is that of the nomenclature of the Royal College of Physicians. The official title of the parasite of malignant tertian has not yet been generally adopted. The parasite has been called *Plasmodium immaculatum* by Schaudinn, *P. falcipariens* by Welch, *P. precox* by Grassi and Felletti, *P. falciparum* by Blanchard, and *Hæmomenas precox* by Ross. *Quot auctores tot nomina !*

TABLE OF THE CESTODA AFFECTING MAN.

Name.	*Length.*	*Characteristics of Head.*	*Eggs.*	*Number of Segments.*	*Intermediary Host.*
1. *Tænia saginata* ..	15 to 20 feet	No hooklets; four suckers; no rostellum; $\frac{1}{13}$ inch in diameter	Oval; thick shell $\frac{1}{850}$ inch in short diameter	1,000 to 1,300, $\frac{1}{2}$ to 1 inch in length	Ox
2. *Tænia solium* ..	7 to 12 feet	Four suckers; double circle of hooklets; has rostellum; size of pin's head	Round; thick brown shell	700 to 800	Pig
3. *Echinococcus hominis*	2 inches	Only $\frac{1}{100}$ inch in diameter; 28 to 50 hooklets in two series; prominent crown surrounding rostellum	Spherical	4	Man
4. *Tænia* or *Hymenolapis nana*	$\frac{1}{5}$ to 2 inches	Four suckers; rostellum; single series of 22 hooks	Oval; thick unmarked shell 30 to 60 microns in diameter	170	Some insect or snail
5. *Tænia* or *Davaina madagascariensis*	4 to 8 inches	Rostellum and 90 hooks	In balls of 400	100	Unknown
6. *Tænia cucomerina* ..	6 inches	Club-shaped, with rostellum and four rows of hooks	Oval	70-80	Dog and cat louse
7. *Bothriocephalus latus*	27 feet	Ovoid; $\frac{1}{10}$ inch in diameter; no hooklets	Lid at one end; brown shell	3,500	Fresh-water fish

CHAPTER XI

THE PREVENTION OF MALARIA

NOWADAYS malaria is chiefly a disease of hot climates, but it was at one time extremely common in Great Britain, as may be gathered from the fact that such great historical personages as King James I. and Oliver Cromwell, the Lord Protector, died of malaria. It is still occasionally met with in the Fen districts of East Anglia, and the infection at Portsmouth of a soldier who had never been out of England is recorded in the *Journal of the Royal Army Medical Corps* for November, 1908.

The disease baffled all treatment until 1640, when the Spanish conquerors of Peru found a remedy for it in a certain bark which grew on the slopes of the Andes. A Spanish lady of rank, Countess Chinchona, first brought the bark to Europe, and endeavoured to introduce it. So furious was the opposition to the "pagan" remedy that she was obliged to confine her ministrations to the peasantry on her own estate. About half a century later, however, the new remedy excited so much discussion, by the numerous cures that it effected, that it was considered worthy of a special council of the Jesuits, who formally pronounced in favour of its use, thereby attaching to it the name of "Jesuit's bark." The enlightened Countess has attained immortality by attaching her own name, Chinchona, softened into *cinchona*, and hardened into *quinine*, to the greatest therapeutic gift of the gods to mankind.

No further progress was made until 1880, when Laveran, a French army surgeon, discovered certain minute parasites in the blood, which were subsequently shown to be the cause of malaria.

It was then observed that the presence of these parasites in the blood was invariably associated with mosquitoes, and, acting on the suggestion that the disease was propagated by them, mosquitoes which had bitten malaria-stricken patients were brought to England, and men who had never been out of England, and never lived in a malarious district, after being bitten by the infected mosquitoes, developed typical attacks of the disease, and the malarial parasites were found in their blood.

An antimalarial campaign was then undertaken in Italy, and it was shown by practical experiments that by either (1) protecting the individual from the bites of mosquitoes, (2) exterminating mosquitoes, or (3) carefully treating all patients, so that no opportunity may be offered to the parasite to enter the mosquito, the disease may be eradicated from a locality.

In Chapter IX. we describe the life-history of the mosquito, and in Chapter X. the rôle it plays in the propagation of malaria, but we may here summarize the facts as follows:

Man and mosquito are required for the propagation of malaria, which passes from man to mosquito and from mosquito to man; but man is by no means alone in his propensity to malarial parasites.

Birds, bats, monkeys, dogs, sheep, horses, and cattle, have their own type of the disease.

It is possible that the malaria of some of the animals is transmitted to man, and that the mosquito that transmits it may not be of the Anopheline variety; and this presumption may explain the outbreaks of malaria in sparsely-populated districts, as,

for instance, the curious outbreak which occurred in 1908 in the Seychelles Island, a locality in which the Anopheline mosquito is believed not to exist.

It is clear, from the evidence that we adduce in Chapter IX., that where malaria abounds it is absolutely necessary that there should be mosquitoes; but it does not necessarily follow that every place where this variety of gnat is found must necessarily be malarious.

The improvement in health of the Fen districts of England did not entirely depend on the extermination of mosquitoes, as at least three species of Anophelines are still found in Great Britain.

The old observations about malaria are very easily explained by the mosquito theory.

Malaria has always been associated with high temperatures and marshy places, which we have seen are necessary for the health of the mosquito.

The malaria mosquito is a night prowler, and flies low; hence the ancient dislike of being out late at night in malarious districts, and the love of the natives of low-lying lands for houses built on piles, or in some way raised from the ground.

Smoke and fire have always had the reputation of keeping off malaria in camps, because they are inimical to mosquitoes.

The rapid growth of aquatic weeds is often attended by the disappearance of larvæ from a pond, and consequently certain localities have seasons characterized by large Anopheline incidence, and also seasons comparatively free from them.

This fact has been put into practice in prevention by planting a tropical aquatic fern called "azolla," which spreads so rapidly that stagnant, and even running, water is rapidly covered. The plan has been tried in India, but found useless.

The fluctuation of the incidence of malaria in

various years may depend on some such influence, or on the varying prevalence of the natural enemies of the mosquito.

The Prevention of Malaria.

The measures for the prevention of malaria come under the following headings :

1. The destruction of mosquitoes and their larvæ.
2. The avoidance of mosquito-bites.
3. Quinine prophylaxis.
4. Quinine disinfection.
5. Segregation of the infected.
6. Good house sanitation.
7. Good urban and rural sanitation.

1. The Destruction of Mosquitoes and their Larvæ.

Mosquitoes and their larvæ may be destroyed by—

(*a*) Chemical methods.
(*b*) Physical methods.
(*c*) Biological methods.

(*a*) **Chemical Methods.**—Amongst the chemical methods which have been found the most efficient are kerosene for oiling breeding-places which cannot be drained, and the burning of pyrethrum powder in rooms which contain mosquitoes. The first method was advocated by Howard in 1892, and has been used with great success in many localities; but collections of water which are thus treated should be frequently inspected, as the film of oil is apt to be displaced by currents or by the movements of aquatic animals. This method of prophylaxis should only be depended upon where it is impossible to drain or otherwise destroy the breeding-places of the insects.

In houses the adult mosquito may be destroyed by burning pyrethrum powder and by sulphur fumi-

gation. These methods are sometimes useful in regions where mosquitoes are numerous, and where it is impossible to destroy their breeding-places or to protect the inmates by the use of screens.

(*b*) **Physical Methods.**—These are the most important, and fall under two headings :

1. Permanent Measures, which consist in engineering efforts to deal with the breeding-grounds once and for all by draining land, filling up pools and ponds, rectification of water-courses, etc.

2. Annual Measures, which consist in the action necessary year by year in dealing with small pools, rain-puddles, collections of water in *gurrahs*,* fire-buckets, and such-like, by which are called "mosquito brigades."

1. **Permanent Measures.**—This variety is, of course, the kind to be hoped for and desired, but such measures involve enormous expenditure, as may be gathered from the following table, which gives some idea of the cost involved in places where such measures have been attended with a large amount of success.

Place.	*Population.*	*Cost per Head.*	*Remarks.*
Ismailia	6,000 to 7,000	6·5 francs initial	Exclusive of quinine.
Klang and Port Swettenham	4,000	£2 10s. initial	Ditto.
Panama	40,000	£10 annually	Inclusive of quinine and sanitary expenditure.

Heavy expenditure of this nature may be possible over a limited area, but where a vast tract of territory has to be dealt with, as in India, it is often difficult, if not impossible, to obtain the money for a campaign of such magnitude.

* Earthenware pots used in India for storing water.

The first essential of antimalarial work is free draining, and as this is naturally attained, more particularly in isolated mountain elevations, such situations are usually free from fever, although paludism is not uncommon in warm mountain valleys, thus showing that to some extent, at least, it is only in proportion as mountains are better drained than the plains that they are more free from breeding-grounds of Anophelines. The districts at the foot of the Himalayas are among the most malarious tracts in India.

In malarious districts, (1) rivers and streams, (2) ditches, (3) irrigation canals, (4) lakes, (5) marshes, and (6) natural and artificial collections of water of all kinds, must be regulated so as to prevent flooding, as most varieties of Anophelines specially favour stagnant water.

The more important systems of dealing with large surface waters are as follows :

(1) *Rivers and Streams.*—The methods of preventing inundation of rivers are—(*a*) Vegetation on mountains and their slopes ; (*b*) steps ; (*c*) traverses and repellents ; (*d*) settling basins and locks ; (*e*) embankments ; (*f*) works of defence against washing away of river-beds ; (*g*) rough canalization.

(*a*) *Woods on Slopes of Mountains.*—These retain a certain proportion of the rainfall, and yield it to streams by slow degrees ; deforested mountains at every heavy fall of rain permit of torrents descending from the slopes, which may cause excessive inundations of the plains. Efforts towards afforestation are therefore antimalarial.

(*b*) *Steps.*—When the slope of mountains and hills is very precipitous, the construction of steps retards the fall of water after heavy rains, and is one of the few ways in which overflow of streams can be prevented.

(c) *Traverses, Repellents, and Dams.*—Traverses formed by trunks of trees and their branches, large stones, and similar forms of obstruction, have been used for centuries in the case of torrential streams and rivulets to check the force of the current.

(d) *Settling Basins and Locks.*—These operate by allowing the water to flow into reservoirs in such a way that overflow of the banks of the river is prevented.

(e) *Embankments.*—These are familiar means of preventing inundations of rivers, which should always be assisted by some form of canalization.

(f) *Paving.*—The paving of the bed of a river has been carried out in a few places successfully. In all cases the banks should be seen to, so that side-pools cannot arise. In the case of small streams, renovating the bed and banks so as to remove the possibility of pools forming is all that is necessary.

(g) *Rough Canalization.*—This process, which has a very wide application, consists in either (1) clearing the centre of streams, ditches, and canals, so as to confine the water channels within two sides of limited surface, or (2) deepening the beds in order to remove marginal pools, and thus give a constant flow of water. Such work should be commenced each year at the end of the rainy season, in order to remove stagnant pools, which might breed mosquitoes.

(2) *Ditches.*—In malarial localities the ditches should be embanked, deepened, and, if possible, paved, so as to be efficient as receptacles for storm water.

When there are a number of springs at the foot of hills, they should be connected so as to form one large spring, in order to avoid the formation of small pools of clean water, which are specially prized by Anophelines as breeding-places.

Anophelines breed especially in sluggish streamlets

of rain water, in stagnant terrestrial water, amongst weeds and grass, in pits or holes in the ground, in hollows in rocks, and in ponds and cisterns. They are not found in *rapid* rivers and streams.

(3) *Irrigation Channels.* — Whenever irrigation works, or any works which will increase the amount of water in the soil are undertaken, it is necessary to simultaneously carry out adequate subsoil water drainage to remove the effluent. Neglect of this in the tropics is invariably associated with increased malarial endemicity in all newly irrigated districts.

One of the chief causes of the prevalence of fevers in agricultural villages and outskirts of towns where rice is the main crop is that the surface soil of the village is kept more or less constantly moist, with the result that the existence of breeding-grounds for Anophelines is universal. This could be obviated by proper arrangements for the reception and subsequent discharge of the irrigation water into prepared channels.

(4) *Lakes.*—Lakes surrounded by shallow pools should be deepened and banked, and the banks kept clear of grass and weeds.

(5) *Marshes and Swamps.* — There are six anti-malarial measures which may be undertaken with reference to marshes and swamps—viz. :

(*a*) The easiest method is that of cutting discharging canals, with a sufficient fall, into some watercourse or depression. The chief difficulties in connection with such canals are (1) the removal of vegetation and (2) the prevention of silting.

In many marshes, the setting free of collections of water by cuttings in the natural direction of the flow are often most useful.

(*b*) In the case of large marshes, intercepting or circumvallatory canals are cheaper and more effective than channels passing through or across them.

(*c*) The third method consists of covering the marsh with alluvium. A river is allowed to flow over malarious land during periods of flood, and there deposits a considerable amount of mud. By this means the area is gradually covered with a stratum of rich mould washed down from higher land. This ingenious method has reclaimed malarious marshes in Italy, and might be applied to certain districts in the tropics.

(*d*) *Absorbing Wells.*—Where the underground stratum consists of gravel, pebbles, etc., which allow of percolation, the level of the underground water can be lowered considerably by sinking wells through the impermeable stratum.

(*e*) *Rubble Drains.*—Channels of requisite depth, cut through or around a marsh and filled with stones, large at the bottom and smaller on top, are useful in lowering the subsoil water level.

(*f*) *Drainage by Exhaustion.*—This measure has been successfully employed for marshes in Italy whose bottom is in some parts lower than sea-level. Ordinary discharging canals would be useless, as there is no fall for the water. The water is raised by special machines, and discharged into channels at a higher level, by which it is conducted to the sea.

(6) *Natural or Artificial Tanks.*—When neglected, these form veritable nurseries for Anophelines, especially the small cisterns used for storing irrigation water in public and private gardens. They should be cemented or lined from edge to bottom with large stones, and furnished with covers.

In the construction of railway lines, engineers should pay special attention to the natural drainage of the subsoil, as a rise in the level of the subsoil water results in marshy patches offering breeding facilities for Anophelines.

Neglect of this principle has been the cause of

many malarial epidemics associated with the building of railways in the tropics.

2. *Annual Measures.*—Annual attacks on all collections of water which may prove possible breeding-grounds are of great value, but have, of course, their limitations.

These measures should be directed against—

1. Water channels.
2. Tanks and pools.
3. Borrow-pits.*
4. Garden cisterns.
5. Disused wells.
6. Brick factories.
7. Grass farms.

These operations are best conducted by mosquito brigades.

The work of these brigades is applicable to towns, collections of villages, gaols, and all large industrial works and factories. They should invariably be organized whenever large gangs of labourers are employed on famine relief works, railway construction, roads, canal works, tea-gardens, extensive building operations, etc. Half a dozen coolies, under one headman, can be taught the duties in a few days, and a few gangs working efficiently can prevent much malaria amongst thousands of labourers.

A mosquito brigade consists of from ten to twenty or more workers, under the direction of a skilled superintendent, the duties of the workers being—(1) To visit regularly once a week the compound of every house, and drain, or fill up with earth, every pool of water which can harbour mosquito larvæ; (2) to cover with a layer of kerosene-oil and pesterine every collection of water which is too large to be otherwise dealt with; (3) to remove all broken tins,

* Excavations made in building operations in the tropics.

pots, bottles, etc., which can contain water ; (4) to instruct the inhabitants in the recognition of mosquito larvæ, and in the methods of destroying them ; (5) to see that by-laws, requiring that all fixed receptacles of water, cesspools, etc., should be made mosquito-proof are carried out, and to bring to the notice of the superintendent any householder in whose premises mosquito larvæ are frequently found ; (6) during the rains to drain off quickly all superficial collections of water in existence for more than a week ; (7) and to endeavour to kill mosquitoes in houses.

The superintendent should make careful observations of the seasonal prevalence of mosquitoes, their habits, and any improved methods which have been found to aid in their extermination.

In towns which extend over a wide area it is necessary, of course, to employ a number of brigades, the town being subdivided into areas of such size that every house and every possible breeding-place of mosquitoes can be visited once a week by a member of the brigades.

Pesterine is preferable as a larvicide to kerosene-oil. Its colour aids the inspecting officer in seeing whether it has been properly applied or not. It is best used with equal parts of kerosene-oil, and by means of an ordinary garden spray. In this way it can be squirted amongst grass and weeds, which otherwise break the continuity of the film and allow larvæ and pupæ to escape destruction.

Three gallons should be used for every 10,000 square yards.

In the case of canals, where the flow is cut off periodically, the oiling should be done after each flow of water.

(*c*) **Biological Methods.**—The natural enemies of mosquito larvæ are fish, frogs, dragon-fly larvæ, and the larvæ of water-beetles.

(1) *Fish.*—Small fish, such as "millions," have a reputation as destroyers of larvæ which they certainly do not deserve. Fish will not eat mosquito larvæ if other food is available.

(2) *Frogs.*—Tadpoles are said to destroy mosquito larvæ, but their frequent presence in the same pools belies this assertion.

(3) *Dragon-Fly Larvæ and the Larvæ of Water-Beetles.*—Dragon-fly larvæ have been largely used in the United States in antimalarial measures, and any-one has only to look for himself at a pool over which these flies are hovering to see how completely mosquito larvæ have been expelled from it.

(4) *Bats, Lizards, and Spiders.*—The enemies of the adult mosquito are bats, lizards, and spiders.

The villagers of some parts of Mexico deliberately introduced a special variety of spider, the *mosquero*, into their houses with a view to ridding them of flies. The results are said to be marvellously good.

These methods have not been very successful in practice, and certainly cannot be depended upon alone in the prophylaxis of malaria.

2. The Avoidance of Mosquito-Bites.

The next method of prevention is defensive. We protect ourselves from being bitten. The measures we can adopt are—

(*a*) Mosquito-proof houses.
(*b*) Mosquito-nets.
(*c*) Mosquito-proof clothes.
(*d*) Agents to prevent mosquitoes biting.
(*e*) Avoidance of certain colours.

(*a*) **Mosquito-Proof Houses.**—Mosquito-proof houses are largely used in America and Italy, and even in some parts of the tropics. They are too costly for general use, but, failing actual mosquito-proof houses,

much can be done, as windows and doors can be protected by gauze, as suggested in Chapter IX.

(*b*) **Mosquito-Nets.**—These cost only a few shillings, and are our chief defensive weapons. They act in two ways: (1) By protecting individuals from contracting malaria; (2) by preventing patients suffering from malaria from becoming a source of infection to others.

For a mosquito-net to be of real use, the bed should be broad, so as to leave a considerable space between the sleeper and the net. The sides and ends of the net must be inside the poles, and the lower border tucked well under the mattress, *not hanging on the ground.* Where poles are not available, the net may be suspended from nails in the wall, or in a tent by pieces of rope or tape fixed in the tent at points corresponding with similar ones in the top corners of the net. If the net is not wide, the lower 2 feet of the net should be lined with calico, which prevents mosquitoes getting at the parts of the body that come into contact with the net during sleep. It should always be let down in the afternoon, and carefully inspected for mosquitoes and sand-flies. A good plan is to make a servant responsible that it is in good repair and free from insects. This is insured by inflicting a fine for any insects found when the net is used. It should be stretched fairly tightly, so as to allow the perflation of air. On getting into bed, the interior should be examined for any mosquitoes that may have strayed in, and any invaders must be captured and killed at once.

(*c*) **Mosquito-Proof Clothing.**—Very thin cotton clothing must not be used in the malarious season, as mosquitoes can bite through it. The feet and hands should be kept covered after sundown, and the favourite feeding-ground of the mosquito and sand-fly—viz., the legs and ankles—should be rendered

inaccessible by wearing drawers and thick socks (the mosquito can bite through thin ones quite easily), and using boots instead of the more comfortable shoes.

(*d*) **Agents that prevent Mosquitoes biting**—*Essential Oils.*—Various chemical and mechanico-chemical agents have been used to apply to the skin of the face, neck, hands, and other exposed parts, to keep off mosquitoes. They are usually odorous substances, such as oil of eucalyptus, oil of rosemary, oil of aniseed, oil of lemon grass, and kerosene-oil, made up in the form of ointment.

The application of the *essential oils* wards off mosquitoes to some extent ; one in great favour in some parts of India is *lemon grass oil*, which is pleasant, harmless, and readily procurable.

The best application is kerosene-oil and lanoline, but, much as the mosquito dislikes it, a hungry female will sometimes feed off a surface covered with it.

With all these applications, as soon as the volatile part of the oil, essence, or ointment, has evaporated, mosquitoes will assuredly begin their attacks. They are effective for the first twenty minutes or half an hour, but are no use afterwards. They merely lull to false security, with the result that one may fall asleep, to be assailed by Anophelines, and possibly infected with malaria, while asleep. When really hungry, mosquitoes will overcome their distaste for all such applications.

(*e*) **Avoidance of Certain Colours.**—The colours blue, dark red, brown, and black, are much more attractive to mosquitoes than white, grey, green, violet, and yellow. These colours should therefore be avoided, and only white garments worn, in malarious regions.

3. Quinine Prophylaxis.

Experienced medical officers in the tropics are not unanimous as to the prophylactic value of quinine, or the best method of administration. Many methods of taking quinine have been recommended, but most of them are purely empirical, and make no allowance for the type of malaria prevalent at the time.

There are five methods, all with a large number of adherents :

1. *Celli's Method.*—Six grains daily.

2. *Plehn's Method.*—Seven to eight grains every fourth and fifth or fifth and sixth day.

3. *Indian Military Method.*—Ten grains twice weekly, with one day interval between the doses. One drachm of sulphate of magnesium to be given with each dose.

4. *Imperial Malarial Conference Method.*—Five grains every evening.

5. *Improved Indian Method.*—The best plan of using the drug is to take 5 grains every evening if the prevalent malaria is mild ; 5 grains daily, with an additional 5 grains once a week, if it is moderately severe, and, in addition, 10 grains if the type is really severe.

The best salt for adults is quinine hydrochloride.

Tannate of quinine is nearly tasteless, and can be used for children.

4. Quinine Disinfection.

What has been described as "the disinfection of the infected" has been tried by Koch on a large scale in German East Africa, with good results.

The method consists in systematic treatment of all infected individuals with quinine.

The blood of all persons in the district is examined, and persons found to be infected are treated as follows :

Fifteen grains on two or three successive days are given at intervals of eight days for three months.

If an individual develops an attack under treatment, he gets—

First and second days, 15 grains morning and evening.

Third, fourth, and fifth days, 15 grains every evening.

After fifth day 15 grains on two or three successive days every eight days for three months.

The plan is only applicable in areas where the patients are under control, such as gaols, barracks, etc.

5. The Segregation of the Infected.

All persons infected with the malarial parasites are the allies of the disease, and essential to its spread, but, unfortunately, the segregation measures we can adopt against them are not numerous, especially as the children of the poorer classes, who are the most prolific sources of malaria, cannot be isolated.

Isolation of malaria cases is to some extent carried out in hospitals in India. As a general measure of protection it is, however, impracticable, but much good may be obtained by keeping malarial patients under mosquito-curtains.

Every European in the tropics should endeavour, by the regular administration of quinine, to limit the number of cases amongst his personal servants; for if one or more of these are infected, their proximity renders him and his neighbours liable to infection through the mosquitoes they infect. In a general way, it may be said that, when malarial fever occurs in a European, he has acquired it from mosquitoes which have previously bitten an infected native, who is more often than not one of the victim's own servants or a child in his compound.

6. Good House Sanitation.

Tropical residents should see personally that larvæ have no chance to breed in their environment, and should also attempt to destroy adult mosquitoes, which may lurk in nooks and crannies in their rooms from one year to another, by fumigating their rooms with sulphur, or less expensive materials, such as the India *gobar* (cow-dung cakes) or bazaar incense, or by spraying them with formalin or other insecticides, such as petroleum emulsion. Thick curtains of all kinds should be removed from living-rooms in hot weather, as they form favourite lurking-grounds for mosquitoes. Clothes hung on pegs should be shaken out and placed in the sun at least once a week.

Large tubs with shrubs in them should not be kept near bungalows, as they often contain larvæ.

Bathrooms should always be well lighted and airy, and accumulations of water in catchpits outside them should not be tolerated.

Kitchens and servants' quarters require special attention.

Servants persist in keeping tubs, jars, and tins, full of drinking or sullage water, or manufacture pools by throwing dirty water on the ground from the kitchens or their own "go-downs."

They have a special predilection for storing jam-tins, sardine-tins, bottles, and other rubbish, behind the kitchen and out-offices. Unless these and their surroundings are regularly inspected by the occupant of a bungalow, and everything of this kind cleared away, plenty of places for mosquitoes to breed will arise. The same remarks apply to servants' latrines, which are particularly attractive to some species of mosquito; indeed, at Ismailia it was found that the great majority of mosquitoes came from the tanks in which excreta were received.

The occupants of a house in a tropical town or village should be held responsible for keeping their bungalows, as far as possible, free from mosquito-breeding conditions. It is obvious that no attempts at general sanitation in the way of drainage will be of any use if good domestic sanitation is not insisted on.

7. Good Urban and Rural Sanitation.

Far more powerful foes of malaria than physical agencies or quinine are a good water-supply, good drainage, good paving, good conservancy, good building organization, and an organized sanitary service to carry out and maintain systematically the necessary sanitary routine.

The chief allies of malaria in the tropics are neglect of ordinary sanitary precautions, and especially puddles and pools in and around buildings, and empty vessels containing water in which the mosquitoes breed.

Malaria disappears before good sanitation, as we know from English experience, and even from our knowledge of some districts in the tropics.

The Epidemiology of Malaria.

The health officer in the tropics is frequently called upon to make a malarial survey before any measures of prevention are adopted.

The procedure to be adopted consists of—

1. Ascertaining the prevalence of malaria by a spleen census.
2. Determining the endemic index.
3. Ascertaining anopheline residents in the locality, and their facilities for breeding.
4. The sporozoite rate.
5. The prevalence of European malaria.

1 and 2. **Spleen Census and Endemic Index.**—These may be taken together.

Avoid a mixed adult and child count. Examine only children between two and twelve. Get influential native to collect children. Bribe with pence, and collect blood-films and examine spleens at same time. Examine blood-films, noting—(1) Number showing parasites ; (2) number showing pigmented leucocytes ; (3) number showing large mononuclear increase.

3. **Facilities for Anophelines and their Species Breeding.**—Collect imago and larvæ, and determine species.* Make map, noting breeding-ground and species found. Make test pool in sheltered place.

4. **Sporozoite Rate.**—Collect as large a number of female Anophelines as possible, and dissect them.

5. **European Incidence.**—In addition to the foregoing, examine blood of as many Europeans as possible, noting as above. Make a map showing relation of native dwellings to bungalows.

With these data the health officer will be able authoritatively to advise his sanitary authority.

* In searching for larvæ in streams or puddles it is important to stir up the water well, as larvæ and nymphæ can be seen better in muddy water.

CHAPTER XII

DISINFECTANTS AND DISINFECTION IN THE TROPICS

THE object of disinfection is, of course, to destroy the germs of disease, but, unfortunately, three groups or agents are usually confused together under this simple heading—viz. :

1. Antiseptics—*i.e.*, substances which arrest the action of bacteria, but do not destroy them, such as boracic acid.

2. Deodorants—*i.e.*, substances which counteract disagreeable odours, such as charcoal, toilet vinegar, and many so-called disinfectants.

3. Disinfectants proper—*i.e.*, substances which really destroy germs, such as carbolic acid.

1. **Antiseptics.**—An antiseptic is an agent which prevents decomposition. The application of this group is limited to substances and places where removal or destruction are undesirable. Its members require the most careful and discriminate employment to be of value in preventing the evil results of infection by pathogenic organisms.

Preservatives are closely allied to antiseptics in their effect upon organic substances, and the preservation of food by physical means, such as (1) cold, (2) exclusion or filtration of air, (3) chemical means—*e.g.*, smoking salting—and (4) the use of various chemical substances, are really antiseptic processes.

Antiseptics merely act by preventing the growth

and development of the micro-organisms which induce sepsis. They do not destroy them.

2. **Deodorants.**—Decomposition and putrefaction are the result of micro-organic life in the resolution of organic substances into their innocuous elements. During this transmutation malodorous gases are given off, and *deodorants* act by overpowering, absorbing, or breaking up, these gases. They produce little or no effect upon the decomposing substances.

3. **Disinfectants Proper.**—Disinfection, in the more restricted and accurate sense, implies the destruction of the infection produced by the specific micro-organisms of disease.

In all the recognized infectious diseases, whether the specific organisms have been found or not, disinfection is applied to the destruction of the specific infection, and the degree to which this destruction is effectually accomplished can be accurately measured.

True disinfectants may be classed under the following headings:

1. Natural disinfectants.
2. Physical disinfectants.
3. Chemical disinfectants.

1. *Natural Disinfectants.*—Fresh air and sunlight will kill most bacteria, whilst living micro-organisms are sooner or later attenuated in their disease-producing activities, and finally killed, by drying.

Thus, the *Spirillum cholera* when dried dies in from three hours to two days.

The *Bacillus typhosus* is destroyed in from half an hour to two hours by direct solar rays, and in five hours by diffuse daylight. The diphtheria bacillus is destroyed by half an hour to an hours' exposure to direct sunlight; whilst Koch found that the tubercle bacillus is killed by the rays of the sun in from a few minutes

to several hours, according to the thickness of the mass exposed.

As no micro-organisms develope in the dry state, the influence of drying on their multiplication is of manifest importance, and the fact makes it clear that the maintenance of the tropical habitation and its surroundings in as dry a state as possible is a stringent sanitary necessity. The frequent airing of bedding and clothing secures the desired dryness, and, in addition, the oxygen of the air exercises a destructive effect on such organisms as may be harboured in these articles; whilst the agitation to which they are subjected in a strong breeze not only mechanically dislodges and removes a considerable proportion of the adherent microbes, but also markedly interferes with the development of certain species.

Nature's disinfectants are, therefore, fresh air, winds, and sunshine.

2. *Physical Disinfectants.*—The physical disinfectants consist of heat in its various forms—viz.:

(*a*) Fire.
(*b*) Hot air.
(*c*) Boiling.
(*d*) Steam.

(*a*) *Fire.*—Destruction by fire is the most thorough means of disinfection, and it should always be employed for articles of little value. When possible, the material should be soaked in kerosene-oil to insure complete and ready combustion.

Bazaar dwellings, which are cheap and readily reconstructed, are best disinfected by fire, especially in such diseases as plague. Whenever such action is taken for portable articles, the employment of a closed incinerator is desirable; for if destruction by fire is carried out in the open air, small unburnt

particles carrying infectious material may be scattered by the action of the wind.

(*b*) *Hot Air.*—This method of disinfection is now discredited, as it has been found to be unreliable.

Its advantages are—(1) It is economical; (2) an ordinary oven can be used for the purpose in emergencies; and (3) within certain limits it does not destroy articles such as furs, leather, india-rubber, and bound books.

Its disadvantages are—(1) It has slow and feeble penetrating powers; (2) it is likely to stain certain articles; and (3) it renders some articles brittle, and damages others.

(*c*) *Boiling.*—One of the best methods of disinfection is boiling. There are few organisms which will stand boiling for a few minutes, and still fewer which will stand a subsequent washing in soap and water.

The disadvantage of boiling is that it is apt to fix albuminous stains; and if it be employed—*e.g.*, for clothes—these must first be soaked in cold water, washed with soap and soda, and then boiled for half an hour. The water in which they have been soaked and washed must also be disinfected by boiling.

(*d*) *Steam.*—Applied in special forms of apparatus, steam is now largely utilized in the tropics for disinfection of bedding and clothing. Its superiority over hot air is due to the following reasons:

(1) *The Large Amount of Latent Heat in Steam.*—Steam in contact with an article to be disinfected, which is at a lower temperature than the steam, undergoes condensation, and in the process parts with its latent heat, thus increasing the temperature of the article. When steam condenses into water, it parts with latent heat to the amount of 893·7 units for every pound of water which was originally converted into steam. Hot dry air, on the other hand, has

no latent heat, but, on the contrary, has its temperature reduced owing to the fact that, before the temperature of the article can be sufficiently raised, any moisture it contains must be evaporated, and the process of evaporation uses up a certain quantity of heat.

(2) *The High Penetrative Power of Steam.*—The condensation of steam is accompanied by diminution in volume, and the creation of a partial vacuum in the interstices of the articles being disinfected. To fill the vacuum, more steam presses forward, and in its turn undergoes a similar process, until every part of the article is penetrated. The pentration of hot dry air, on the contrary, depends entirely on conduction and convection, and dry air is a slow conductor. Moreover, the diminution in volume of hot dry air on being cooled is trifling compared with that produced in the condensation of steam.

(3) A lower temperature continued for a shorter time suffices for adequate disinfection.

(4) The risk of fire is slight. Fabrics and material other than paper, leather, feathers, and rubber, are not likely to be injured.

The various types of apparatus used for disinfecting by steam have been classified as follows :

1. Apparatus in which steam without pressure is employed. These are cheaper, but, as the temperature of the steam does not exceed 100° C., they are less efficient than the next two types.

2. Apparatus in which steam at low pressure, such as 2, 3, or 5 pounds per square inch, is relied on. The highest temperature which can be reached by these stoves is 110° C. This is generally sufficient for all practical purposes, and these disinfectors are cheaper than high-pressure varieties.

3. Apparatus in which steam at high pressure, such as 10 pounds and over, is employed. A temperature of 115° to 120° C. can be obtained in these

stoves, and an exposure of articles from a quarter to half an hour suffices for their disinfection. The higher the pressure of the steam, and the more rapid the penetration, the less the time required for disinfection.

The health officer must have clear notions on *saturated* and *superheated* steam.

(1) Saturated steam is steam at the temperature at which it condenses, and the temperature of the condensation-point rises as the pressure increases. (2) Superheated steam is steam at a temperature higher than that at which it can condense; therefore superheated steam has to be cooled down into the state of saturated steam before condensation ensues. If superheated steam is used for disinfection, it loses heat by conduction, and the rise in temperature of the articles treated approximately corresponds to the fall in the temperature of the steam. With saturated steam, on the other hand, immediately it is cooled an enormous amount of latent heat is set free by the change in state from the gaseous to the liquid condition; therefore saturated steam is a far more efficient disinfectant than superheated steam. These considerations should always influence the medical officer in his choice of a steam disinfecting apparatus.

There are three varieties of disinfecting apparatus in common use in the tropics—viz.:

(1) The Washington Lyons.
(2) The Equifex.
(3) The Thresh.

(1) *The Washington Lyons Apparatus.*—This apparatus is oval in section, and is usually worked with a pressure of 10 pounds per square inch in the jacket, and 5 pounds in the chamber, so that the steam in the latter is superheated, a precaution against condensation. The articles having been introduced

and the doors closed and secured, steam is first directed into the jacket, so as to heat the contents of the chamber. Steam is next admitted into the chamber itself, and soon reaches the full pressure required. It is found that penetration is more rapid if the pressure is intermitted once or twice. This is readily effected by turning a cock. Ten to twenty minutes suffice for the penetration of even bulky articles, and at the end of that time the steam is allowed to escape from the chamber, the door is opened, and the articles dried by exposing them to the heat from the jacket for a few minutes.

(2) *The Equifex.*—This type is worked with a saturated, not superheated, steam, at 239° F., with 10 pounds pressure. The chamber consists of a steel cylinder made without a steam-jacket, so as to avoid the risk of superheating. The cylinder is packed with non-conducting composition, and covered with wood, so as to reduce loss of heat by radiation. Separate doors for infected and disinfected articles are provided.

(3) *The Thresh Apparatus.*—In this form of apparatus, current steam, at a temperature of 225° F. and not under pressure, is used. The steam at this temperature is obtained by using a saline solution, which boils at a higher temperature than water.

The process is continued for about twenty minutes, and at the end of that time a current of previously heated air is drawn through the chamber to dry the disinfected articles.

The apparatus is simple, efficient, and cheap.

3. *Chemical Disinfectants.*—The number of chemical disinfectants on the market is enormous. They may be divided into—

(*a*) Gaseous.
(*b*) Liquid.
(*c*) Solid.

(*a*) *Gaseous Disinfectants.*—The principal gaseous disinfectants are burning sulphur, formaldehyde, and chlorine.

Burning Sulphur.—The gas produced by burning sulphur has been in use for centuries as the most convenient form of gaseous disinfectant. It is essential that all surfaces with which the gas is to come into contact should be thoroughly damped, as the gas only acts in the presence of moisture.

Rolled sulphur or the specially-prepared candles should be used, as powdered sulphur is frequently impure. Two pounds of sulphur are required for each 1,000 cubic feet of space.

Formaldehyde.—This gas, liberated from tablets by heating in some special form of lamp, has largely replaced sulphur of recent years.

It may be readily generated by pouring formalin on permanganate of potash.

The proportion of the two substances which gives the best results and the driest residue is 2 parts of formalin to 1 part of permanganate. The method is very effective, simple, rapid, and, by virtue of the inexpensive apparatus required, preferable to the older and more cumbersome methods.

One pint of formalin poured on 10 ounces of permanganate in an ordinary galvanized iron pail is sufficient to efficiently disinfect 2,000 cubic feet. The period of disinfection should be six hours. From 60° to 70° F. is a proper temperature, and the air of a room must be rendered moist in a dry country.

The Lingner apparatus for the formalin spray has been used with success in Western India.

Chlorine.—This element is useful as a disinfectant, but is a powerful bleaching agent, and should only be used where the other two gases mentioned are not available. Half a pound of hydrochloric acid, or any

other mineral acid, will liberate the gas from 2 pounds of chlorinated lime.

It should be borne in mind that the *air* of an infected room can readily change, and therefore does not require disinfection. Moreover, micro-organisms have weight, and do not remain in the air, but sink on the floors, walls, furniture, so our attention should be devoted to them.

(*b*) *Liquid Disinfectants.*—There are several substances or groups of substances in common use in the tropics as liquid disinfectants.

The following table shows (1) the strength in which they must be used to act as efficient germicides; (2) their carbolic acid coefficients—that is, their germicidal power compared with phenol regarded as unity.

TABLE OF DISINFECTANTS SHOWING CO-EFFICIENTS AND STRENGTHS IN WHICH THEY SHOULD BE USED.

Disinfectant.	*Carbolic Acid Co-efficient with B. Typhosus.*	*Strength recommended.*
Chinosol	0·15	1 per cent.
Cyllin	14	½ ,,
Formalin . .	0·7	3 ,,
Izal	11	½ ,,
Kerol	12	½ ,,
Lysol	2·5	1 ,,
Mercuric chloride	1,000	0·01 ,,
Mercuric iodide . .	1,000	0·01 ,,
Zinc chloride . .	0·15	5 ,,
Carbolic acid . .	unity	5 ,,
Saponified Cresol	12	½ ,,
Potassium permanganate . .	42	5 ,,

(*c*) *Solid Disinfectants.*—We can only refer to five substances under this heading—viz. :

(1) Lime.
(2) Chloride of lime.
(3) Permanganate of potash.
(4) Ferrous sulphate.
(5) Soap.

(1) *Lime.*—Freshly-burned lime is a cheap and useful germicide. In the form of whitewash, it is a disinfectant which plays a useful part in the tropics. It is important to see that lime used for disinfecting purposes is fresh ; for if stored for any length of time, the action of the air converts a large amount of it into calcium carbonate, which has no germicidal properties.

Some authorities have found that ordinary whitewashing destroys all micro-organisms except those of anthrax and tuberculosis.

Prior to the application of whitewash, the surface should be well scraped, as we should aim at the removal of bacterial life rather than its burial even under a germicide.

(2) *Chloride of Lime.*—Bleaching-powder is a powerful but disagreeable deodorant, and a disinfectant of considerable power. It consists of lime saturated with chlorine, and is of very unstable composition. It corrodes metals and blocks drains.

It was formerly largely *misused* to hide offensive odours. Its chief legitimate use in the tropics is to keep off flies, but for this purpose crude petroleum is better.

(3) *Permanganate of Potassium.*—When used in 5 per cent. solution it is a powerful disinfectant, but as generally used, in less than $\frac{1}{2}$ per cent. solution, it merely acts as a weak deodorant. It has the following disadvantages : (*a*) It is expensive ; (*b*) it stains fabrics ; (*c*) it is easily reduced to an inert form.

It is used with advantage in the disinfection of wells.

(4) *Ferrous Sulphate.*—Green copperas acts mainly by its reducing action, a process in which it absorbs oxygen. It is a feeble disinfectant unless used in great strength (20 to 30 per cent.), but it is a good deodorant, absorbing ammonia and sulphuretted hydrogen.

In practice it is suitable only for excreta, as it stains badly and tends to form iron-moulds.

(5) *Soap.*—Common soap is one of the most generally useful of the chemical disinfectants.

The alkali in ordinary household soap not only actually destroys germs, but also tends to dissolve the outer covering of their spores. It also washes away the greasy materials which frequently protect bacteria from the action of the natural disinfectants, sunlight and oxygen, and is therefore a very valuable purifier.

When a case of infectious disease occurs, the following rules should be observed :

1. Whenever a steam-disinfector is available, all articles of bedding, carpets, hangings, etc., which are not likely to be injured by steam, should be sent to the disinfecting-station.

2. When a steam-disinfector is not available, cotton and linen articles should be boiled for half an hour. Blankets and other woollen articles, and coir fibre, should be soaked for two hours in saponified creasol. Cloth articles should be sprayed with a 5 per cent. solution of pure carbolic acid in water, and exposed to the sun for three or four days. Leather articles should be sponged with a 1 per cent. solution of formalin.

3. Feeding and cooking utensils should be boiled for fifteen minutes. Immersion in a 20 per cent. hot solution of washing soda suffices, however, for most

infectious diseases; but it will not serve in cases of infection by the tubercle bacillus. Table-knives. mounted forks, and similar articles, should be soaked for two hours in a 1 per cent. solution of formalin.

4. The walls of the room occupied by the patient should be scraped and re-limewashed.

5. Furniture, floors, and woodwork, should be scrubbed with hot water and soap.

6. Earthern floors should be saturated with a disinfectant preparation, preferably kerosene emulsion with 2 per cent. of cyanide of mercury.

7. The woodwork of the latrine used by the patient should be scrubbed with a mercuric chloride solution (0·05 per cent.), and the floor saturated with the same solution.

It is often a wise precaution to disinfect any adjacent well by adding 2 ounces of quicklime or $1\frac{1}{2}$ drachms of permanganate of potassium to each gallon of water it contains. In adding the solution of permanganate of potassium or emulsion of lime, care should be taken to wet each part of the well. The formula for calculating the amount of lime necessary to disinfect a well is: (Diameter of well in feet)^2 $\times$ (depth of water in well in feet) = number of pounds of lime required.

The answer to the same formula divided by 10 will give approximately the number of ounces of permanganate of potassium required.

The Destruction of Insects.

Good disinfectants are not necessarily good insecticides—as, for example, mercuric chloride, which, although it is one of the most powerful of all disinfectants, has little influence on insect life.

A recent laboratory experiment has shown that fleas will emerge unscathed from an exposure of ten minutes in an acid solution of corrosive sublimate

of such a powerful strength as 1 in 500. Moreover, the disinfecting action of this chemical is considerably neutralized by organic matter on floors and walls, and especially in the case of mud floors of native huts and houses which are smeared with cow-dung.

The best insecticides are—

1. Pesterine.
2. Kerosene-oil emulsion.
3. Kerosene-oil and cyanide of mercury solution.
4. Petrol.
5. Saponified cresol.
6. Sulphur dioxide gas.
7. Formaldehyde.

The last three in the above list have already been dealt with. The first four, however, require brief special mention.

For general purposes the gaseous disinfectants should be used chiefly as insecticides. For efficient use as disinfectants, the rooms to which they are applied should be carefully sealed up, and this is a very difficult procedure with the ordinary tropical room.

In a strength far short of that in which they will destroy bacteria, they will, however, act as efficient poisons to mosquitoes and other biting flies which survive in nooks and crannies from one year to another.

1. **Pesterine.**—This substance is crude petroleum (fuel-oil), and is undoubtedly a powerful insecticide, as it instantly kills all fleas, bugs, and other insects, that come in contact with it. Its method of application is very simple, as it has only to be brushed on the floors and the walls of rooms to a height of about 3 feet. It is very cheap, as the cost of treating an average-sized room is only about one shilling. It is not, however, an elegant preparation; hence its use in better-class houses is open to some objections.

2. **Kerosene-Oil Emulsion.**—This emulsion is made according to the following formula: Common soap, 3 parts; water, 15 parts; kerosene-oil, 82 parts.

The soap is dissolved in the water by aid of heat, and the kerosene-oil is warmed and gradually stirred into the mixture.

It has been shown that 1 part in 1,000 parts of this solution will kill fleas in two minutes.

It should ordinarily be used diluted with 20 parts of water.

3. **Kerosene-Oil and Cyanide of Mercury.**—This compound consists of 2 parts of cyanide of mercury added to each 100 parts of kerosene-oil emulsion.

Where cost is not the chief consideration, as is too often the case in the tropics, this compound is an ideal preparation for disinfecting native houses, as it is not only an efficient insecticide, but powerful disinfectant.

4. **Petrol.**—This fluid was used with equal parts of cyllin for disinfecting plague-stricken houses in Hong-Kong. The mixture has to be made up fresh daily, as the two ingredients undergo chemical changes, producing an inert substance. The emulsion is a powerful insecticide and germicide.

All things considered, pesterine or kerosene-oil emulsion fulfil all requirements.

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APPENDIX I.—TABLE OF TROPICAL DISEASES INDICATING PREVENTIVE MEASURES.

Disease.	*Mode of Infection.*	*Duration of Illness.*	*Duration of Infectivity.*	*Preventive Measures.*	*Quarantine Period for Contacts.*
Malaria	Through anophelines which bite infected persons, and some time afterwards convey the parasite to healthy individuals	Varies with type of fever	So long as parasites are to be found in the blood	(1) Aim at extermination of mosquitoes of all kinds; (2) protect from mosquito-bites; (3) take 5 grains of quinine daily	There are three types of malaria due to different parasites. Two of these varieties are readily cured by quinine, whilst the third is not
Cholera	From excreta, through water, food, dust, flies, or clothing	A few hours up to 5 days	Till discharge is free from cholera bacilli	(1) Drink nothing but tea or boiled water; (2) avoid raw fruits and vegetables; (3) sulphuric acid lemonade	5 to 10 days
Dysentery	As enteric	Variable	Whilst the bacilli or amœbæ which cause the disease are to be found in the stools	(1) Isolation; (2) disinfection of excreta	As enteric
Typhoid fever	From excreta, through water, milk, food, dust, and flies	21 days or longer	From 1 month or longer. "Typhoid-carriers" harbour germs for long periods	(1) Isolation; (2) disinfect most strictly all urine, stools, and everything that has been used in connection with the patient; (3) preventive inoculation; (4) habitually avoid food without skins and uncooked vegetables; (5) destroy flies	All contacts and persons who have been nursing enteric cases should be quarantined for a month
Paratyphoid	As enteric	Variable	As enteric	As enteric	As enteric
Plague	From rats through fleas	About 1 month. Many cases die on 3rd to 5th day	6 to 8 weeks	(1) Isolation and disinfection; (2) discouragement of rats; (3) preventive inoculation; (4) protection of feet and hands, especially abraided surfaces	12 days
Pneumonia	Through air, sputum, food, or indirectly through a third person	Crisis may be expected on 6th to 8th day.	24 days	Isolation and careful disinfection	7 days
Smallpox	Through air and breath	14 to 21 days	About 1 month. A corpse is as infective as a living person.	All contacts must be vaccinated	16 days
Tuberculosis	Through air, sputum, milk, food, clothing, and flies	Variable	In tubercle of lung exists throughout the disease	(1) Isolation of infected person, if possible; (2) disinfection of clothing, etc.; (3) efficient inspection of milk cows; (4) disinfection of sputum; (5) prevention of spitting; (6) banish flies	21 days
Pellagra	Ingestion of diseased maize; ? midges or sand-flies	Mild cases recover in 6 months, but recovery is very rare	None at all	(1) Proper drying of maize and provision of hygienic bakeries; (2) protection from bites of midges	
Relapsing fever	From bed-bugs which bite person during paroxysmal stage	Usually 3 weeks	Only during febrile period	(1) Maintain complete cleanliness of room, etc.; (2) aim at extermination of bed-bugs; (3) careful disinfection of clothing, bedding, and furniture, used by patient	14 days
Yellow fever	From bites of *Stegomyia fasciata*	1 to 2 weeks	4 weeks	(1) Protect patient from mosquito-bites during first three or four days of illness; (2) enforce carefully all measures against mosquitoes detailed in Chapter XI.	12 days. This period is meant to indicate the time after which *Stegomyia* which has bitten yellow-fever patient becomes infective
Malta fever	(1) Drinking infected goat's milk; (2) inoculation with living cultures	Extends to long periods	So long as *Micrococcus melitensis* is present in urine of patients	(1) Avoid goat's milk, or boil it thoroughly; (2) bacteriologists should exercise care in working with living cultures of *Micrococcus melitensis*	
Sand-fly fever	From bites of *Phlebotomus papatassi*	Varies with types a week to a fortnight	Only during febrile stage	(1) Protection by fine gauze mosquito-nets; (2) improved housing; (3) removal of breeding-places (*vide* Chapter IX.)	
Kala-azar	From bites of bed-bugs, *Cimex rotundatus*	Variable	During course of illness	(1) Exterminate bed-bugs and all insect life; (2) isolation of patient; (3) prevent migration of sick to healthy places	The clothing of all contacts should be carefully disinfected

[*Between pages* 188 *and* 189.

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